measurement SPECIALTIES™

# Model 9116
# Intelligent Pressure Scanner
# User's Manual

**August 2012**


NetScanner™ System

www.meas-spec.com

| REVISION | REVISION HISTORY | PRINT DATE |
|---|---|---|
| 1 | Updated manual terminology and deleted all references to UDP Query and to O-ring part numbers. | April 2004 |
| 2 | Update terminology | November 2004 |
| 3 | Update commands | August 2007 |
| 4 | Update to MEAS information | August 2012 |
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# Preface

This manual describes the **NetScanner™ System** Intelligent Pressure Scanner module (**Model 9116**). It does not cover the pressure scanner Models 9016, 9021, 9022, the 98RK Scanner Interface Rack, Model 9816 Intelligent Pressure Scanner, nor Models 903x (Pressure Standards/Controllers. These products are covered in their individual User's Manuals.

This manual is divided into six (6) chapters and several appendices, each covering a specific topic. They are summarized below:

| | | |
|---|---|---|
| **Chapter 1:** | **General Information** | describes **Model 9116** Intelligent Pressure Scanner and its various options. |
| **Chapter 2:** | **Installation and Set Up** | describes the unpacking and inspection of a module, and its connection to power, pressure, and a communications network. |
| **Chapter 3:** | **Programming & Operation** | provides the information needed to program a module from a host computer and to get meaningful data from it. |
| **Chapter 4:** | **Calibration** | describes methods of calibrating a module. |
| **Chapter 5:** | **Service** | describes general safety precautions and maintenance procedures. |
| **Chapter 6:** | **Troubleshooting** | describes module troubleshooting techniques. |
| **Chapter 7:** | **Start-up Software** | briefly describes **NUSS** software. |

**Appendix A: All Commands — Quick Reference**
**Appendix B: Response Error Codes**
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# Our Company

Measurement Specialties Incorporated, (MEAS) develops, manufactures, and services level and pressure measuring instruments where the highest level of traceable accuracy is required for aerospace, industrial, municipal, and environmental applications. Our products have become the world standard for electronic level and pressure measurement and scanning. We are committed to the highest quality design, manufacture, and support of level and pressure instrumentation that is in the best interest of our customers. MEAS is an ISO-9001:2000 certified company.

# Our Warranty

Measurement Specialties, Inc., warrants **NetScanner™ System** products to be free of defects in material and workmanship under normal use and service for one (1) year.

# Technical Support

Monday through Friday, during normal working hours, (7:30 am through 5:30 pm, Eastern time) knowledgeable personnel are available for assistance and troubleshooting. Contact the **Applications Support Group** or the **Customer Services Department** at Measurement Specialties (**757-766-1500** or toll free **1-800-745-8008**) if your scanner is not operating properly or if you have questions concerning any of our products. E-mail assistance is available by contacting Applications@meas-spec.com.

# Merchandise Return Procedures

If your scanner needs to be returned to Measurement Specialties, please obtain a Returned Merchandise Authorization (RMA) from the Customer Service Department.

Be prepared to supply the following information when requesting the RMA:

- Part number
- Serial number
- Complete description of problems/symptoms
- **Bill To** and **Ship To** address
- Purchase order number (not required by MEAS warranty repairs)
- Customer contact and telephone number

The above information, including the RMA number must be on the customer's shipping documents that accompany the equipment to be repaired. MEAS also requests that the outside of the shipping container be labeled with the RMA number to assist in tracking the repairs. All equipment should be sent to the following address:

ATTN: MEAS REPAIR DEPARTMENT (7-digit RMA number)
Measurement Specialties, Inc.
1000 Lucas Way
Hampton, Virginia 23666

MEAS will return warranty items prepaid via UPS GROUND. If the customer desires another method of return shipment, MEAS will prepay and add the shipping charges to the repair bill.

Incoming freight charges are the customer's responsibility. The customer is also responsible for paying shipping charges to and from MEAS for any equipment not under warranty.

All products covered under the MEAS warranty policy will be repaired at no charge. An analysis fee will be charged to quote the cost of repairing any item not under warranty. If, for any reason, the customer decides not to have the item repaired, the analysis fee will still be charged. If the quote is approved by the customer, the analysis fee will be waived. The quote for repair will be based on the MEAS flat rate for repair, calibration, and board replacement. When these prices do not apply, the quote will be based on an hourly labor rate plus parts. All replaced parts are warranted for 90 days from the date of shipment. The 90-day warranty is strictly limited to parts replaced during the repair.

# Website and E-Mail

Visit our website at www.meas-spec.com to look at our new product releases, application notes, product certifications, and specifications. E-mail your questions and comments to us: Sales@meas-spec.com.

# Our Firmware

This manual was prepared for various versions of module firmware as were released at the time of this manual publication. Addenda will be distributed as deemed necessary by MEAS. Any questions regarding firmware upgrades may be addressed to the **Applications Support Group**. Firmware revisions, manual addenda, and utility software may also be obtained from the MEAS web page at www.meas-spec.com.

# Our Publication Disclaimer

This document is thoroughly edited and is believed to be thoroughly reliable. Measurement Specialties, Inc., assumes no liability for inaccuracies. All computer programs supplied with your products are written and tested on available systems at the factory. MEAS assumes no responsibility for other computers, languages, or operating systems. MEAS reserves the right to change the specifications without notice.

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# Chapter 1

# General Information

## 1.1 Introduction

This User's Manual will:

- Explain the electrical and pneumatic pressure connections for the **Model 9116** Intelligent Pressure Scanner.
- Provide computer set-up instructions to make a proper Ethernet connection on most Windows® 95/98/XP/NT-based personal computers.
- Instruct you on using the start-up software to manipulate and acquire data from each module.
- Instruct you on how to program each module with computer software.

Model 9116 is a pneumatic Intelligent Pressure Scanner, with integral pressure transducers and a pneumatic calibration manifold.

The Model 9116 provides engineering unit pressure data with guaranteed system accuracy. This is achieved by reading factory-determined pressure and temperature engineering-unit data conversion coefficients from its transducers' nonvolatile memories at power-up. It also allows additional adjustment coefficients to be "fine-tuned" with a multi-point calibration under host control (e.g., possibly utilizing optional 903x Pressure Calibrator modules).

Model 9116 provides an auto-configuring 10BaseT/100BaseT Ethernet communications port. Half duplex/full duplex operation is also automatically configured. The Model 9116 communicates using the TCP/UDP/IP protocols.

The Model 9116 Intelligent Pressure Scanner is a component of a networked data acquisition concept called the NetScanner™ System. Multiple NetScanner modules measuring a wide variety of parameters can be networked to form a distributed intelligent data acquisition system.

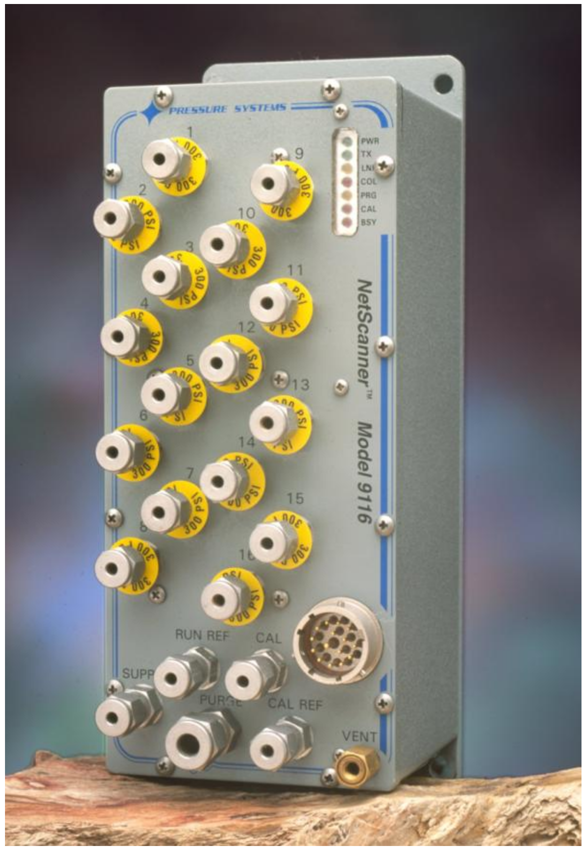



**Figure 1.1**
**Model 9116 Intelligent Pressure Scanner**

## 1.2 Description of the Instrument

The Model 9116 is available with16 channels, each with individual pneumatic transducers per channel. The most distinctive features are highlighted below:

- Pre-calibrated Transducer - a memory chip containing full calibration data is embedded within each internal transducer.

- Individual transducer per measurement input channel - mixed transducer ranges may be installed in a single Model 9116 module.

- Low cost per point - per-channel cost is less than a typical industrial pressure transducer/transmitter.

- High accuracy - **Model 9116** pressure scanners are capable of accuracies up to ±0.05%. Accuracy is maintained through use of built-in re-zero, span, or multi-point calibration capabilities. Accuracies are maintained for six (6) months after calibration.

    - Low thermal errors - each internal transducer contains an individual temperature sensor and thermal calibration data for internal use by software correction algorithms. Thermal errors are reduced as low as ±0.001%FS/ºC over the calibrated temperature span.

    - Re-zero upon demand - an integrated calibration valve allows for automatic re-zero adjustment calibration of dry gas transducers to null offset drift errors.

    - Ease of transducer replacement - factory calibrated transducer assemblies may be stocked and rapidly replaced in the field. Storage of thermal coefficients within the transducer allows for '**plug and play**' transducer replacement.

    - Ease of calibration - each **Model 9116** module contains a pneumatic calibration manifold and software commands to automatically perform re-zero, span, and multi-point adjustment calibrations. New offset and gain coefficients that result from the most recent calibration may be stored in non-volatile transducer memory.

    - Ease of use - modules have simple command sets and provide engineering units output. They may interface directly to a desktop or laptop computer or they may be interconnected into a large network controlled by many types of host computers.

    - Connectivity - use of industry-standard communications network protocols to control and read data from **NetScanner™ System** modules allows distribution to the point of measurement and ensures compatibility with third party hardware and software.

### 1.2.1 Differences Between Models 9016 and 9116

The all new electronics of the **Model 9116** reduces data acquisition noise and capture latency, while actually improving channel settling time and boosting data throughput. Additionally, the Ethernet interface has been upgraded to 10BaseT/100BaseT with half and full duplex capabilities to provide significant flexibility in network configuration. The Ethernet interface is completely auto-configuring, ensuring the best utilization of network capabilities, while ensuring the maximum backward compatibility. The trigger circuitry has been upgraded to allow triggering on positive, negative, or both transitions of the trigger signal. By configuring the **Model 9116** to trigger on both transitions, the **Model 9116** can be integrated into existing systems, providing twice the data throughput for most users, without modification to the system trigger circuit.

The firmware in the **Model 9116** implements the Model 9016 command set further simplifying use with existing systems. In fact, the **Model 9116** can be configured to report its identity as a Model 9016 to ensure compatibility with system software that is sensitive to the reported model type.

Consolidated below are the new commands added to the Model 9016 command set, as well as differences in existing commands, command parameters, or command responses:

**Set Module type alias**: w3200 xxxx
See the **'SET/DO OPTION/FUNCTIONS'** (command '**w**')' in **Section 3.2**.
Configures the **Model 9116** to report its model type as **Model 9116** or as a Model 9016 for compatibility with model type sensitive system software.

**Set Hardware Trigger Mode**: w320x
See the **'SET/DO OPTION/FUNCTIONS'** (command '**w**')' in **Section 3.2**.
Configures the trigger to response to positive going, negative going, or to any transition on the trigger input.

**Query the Hardware Trigger Mode**: q32
See the **'READ MODULE STATUS'** (command '**q**')' in **Section 3.2**.
The **Model 9116** will respond with a 1, 2, or 3 indicating, respectively, that its trigger is set to respond to a positive going, negative going or to any transition on the trigger input. The Model 9016 will respond to this command with an 'N08'.

**Query the Module Hardware Version**: w31
See the **'READ MODULE STATUS'** (command '**q**')' in **Section 3.2**.
The **Model 9116** will report the version of hardware present as a floating point number of the format x.xxxxxx The Model 9016 will respond to this command with a 'N08'.

Modifications to existing commands, (See **Section 3.2**):

In the **'CONFIGURE A HOST DELIVERY STREAM'** (command '**c**'), the sync delay can now be set as small as 2 milliseconds and the granularity is 2 milliseconds with all other values rounded down to the nearest 2 milliseconds. This value was 10 milliseconds in the Model 9016.

In the Set **Number of A/D Samples to Average,** (command '**w**'). the minimum value and the default value is 4. The interleaved instrumentation amplifiers utilized in the **Model 9116** allows it to provide the same throughput with one to four averages. With the quieter electronics of the **Model 9116** and no speed advantage for lower numbers of averaged samples, the minimum and default is set to four. Valid values are 4, 8, 16, 32, and 64. Other values below 64 are rounded up to the next valid value listed above."

Additional enhancements to the **Model 9116**

**Software Scan List Speeds**:

Software Scan lists can be run as fast as hardware trigger scan lists on the **Model 9116** (~500 Hz. See specification sheet). The Model 9016 was limited to 100 Hz maximum software trigger scan lists.

**Firmware Updates/Boot Loader**:

The firmware in the **Model 9116** may be updated in situ, over its Ethernet connection. This is the preferred method for updating the firmware and may be invoked at any time. (See **Section 5.2.1**).

The user must connect to the updated module. Establishing a TCP/IP connection is the last step in validating a successful firmware update. If the unit is power-cycled four times without establishing a TCP/IP connection, the firmware update will be tagged as invalid. The **Model 9116** contains a protected resident boot loader that will then take over operation of the module. The resident boot loader resides in protected memory. It monitors the state of the firmware and the operation of any downloads. Even in the event of a power failure during a firmware update, upon return of power, the resident boot loader will be available, and will establish communications for downloading new firmware. The user can determine that the **Model 9116** is in boot loader mode by observing that the firmware version reported by the module is less than 1.0 In boot loader mode, the **Model 9116** will return an 'N08' in response to the 'a', 'c', 'm', 'n', 'r', and 't' commands.

# 1.3 Options

## 1.3.1 Pressure Ranges

**Model 9116** contains sixteen (16) DH200 transducers. These transducers are available with full scale pressure ranges from 10" $H_2O$ (inches of water column) to 750 psid (2.5 kPa to 5200 kPa). Transducers with different pressure ranges may be combined in a single module.

Please consult the Sales Department at Measurement Specialties for availability of other pressure ranges (1-800-678-SCAN (7226)).

## 1.3.2 Manifolds and Pressure Connections

**Model 9116** sixteen-channel Intelligent Pressure Scanners are available with a true differential or common reference pneumatic manifold, and have a standard purge and leak check manifold. They are available with standard 1/8" or optional 1/16" and 1/4" compression fittings. All fittings utilize an SAE 5/16 - 24 O-ring boss which supports a variety of other adapter compression fittings. They are also available with a quick disconnect plate which contains 0.063" bulge tubulation. The common differential version is available with all choices of fittings. The true differential version is available with 0.063" bulged tubulation fittings only.

Consult the Sales Department at Measurement Specialties at 1-800-678-SCAN (7226) for availability of other input fittings.

### 1.3.3 Communication Interfaces

All standard **NetScanner™ System** Intelligent Pressure Scanners provide temperature compensated and linearized pressure data in engineering units via digital methods. They have a 10BaseT Ethernet host communications interface using industry standard TCP/IP or UDP/IP protocol. This interface provides high data transfer rates and system connectivity. The **Model 9116** adds auto-configuring 10BaseT/100BaseT, half duplex/full duplex capabilities for improved network flexibility.

# Chapter 2

# Installation and Set Up

## 2.1 Unpacking and Inspection

The **NetScanner™ System** product family has many components which may be purchased either as an entire system, or as individual pieces of equipment. Before assembling the system, use the shipping bill as a reference to ensure that all parts have arrived. Measurement Specialties takes no responsibility for equipment that is damaged during shipment. If containers are broken, ripped, or damaged, contact the transportation carrier. If the equipment itself appears to be damaged, contact Customer Service at Measurement Specialties.

Each **Model 9116** Intelligent Pressure Scanner shipment will contain the following minimum components:

- **Model 9116** Intelligent Pressure Scanner module
- Start-up software CD-ROM
- **Model 9116** User's Manual for Intelligent Pressure Scanners CD-ROM

## 2.2 Safety Considerations

It is always a good idea to wear safety glasses when operating this equipment or when working with pressurized lines. Always ensure that high pressure lines are properly secured and that all pneumatic lines are rated for the proper pressure and temperature environments.

All system power should be **OFF** during installation (or removal) of any components in a **NetScanner™ System** module. Failure to turn power **OFF** prior to installation may cause permanent damage to the module. Use caution and check line voltages before applying power to the module.

## 2.3 Preparation for Use

### 2.3.1 Environment

All standard Intelligent Pressure Scanners are factory calibrated to be accurate over a specified temperature range, but may be operated or stored over a wider temperature range (see **Environmental/Physical Specifications** in the **Model 9116** Data Sheet. Operating or storing an instrument outside its specified range(s) will result in a loss of measurement accuracy and may cause permanent damage to the instrument electronics.

**WARNING: Exceeding the specified storage or operating temperatures may result in permanent damage to the Model 9116 electronics.**

## 2.3.2 Power

The **Model 9116** Intelligent Pressure Scanner needs only a single unregulated power supply. See the **Model 9116** Data Sheet for actual power requirements.

**Model 9116** has a single round, ruggedized connector through which all power and input/output signals pass as shown in **Figure 2.1**.

**WARNING: Improper connection of power to the Intelligent Pressure Scanner can result in permanent damage to module electronics.**

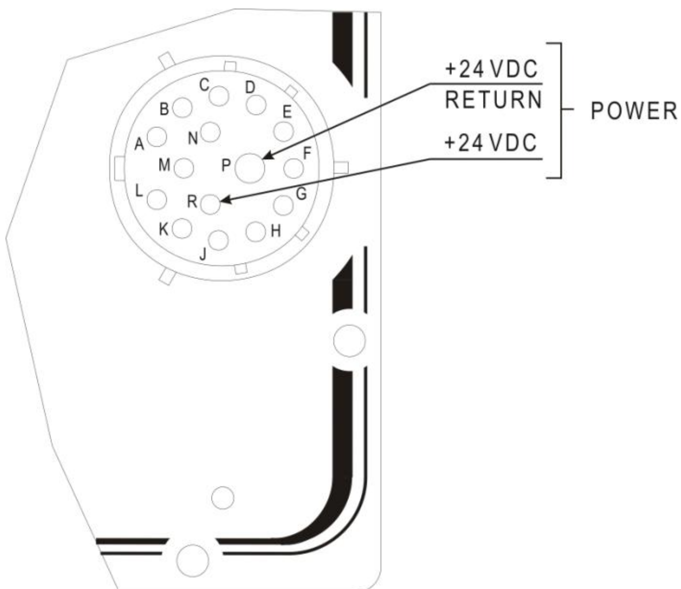



**Figure 2.1**
**9116 Power Pin Assignments**

### 2.3.3 Mounting and Module Dimensions

See the **Model 9116** Data Sheet for exact dimensions of the module. A detailed mechanical drawing is also included in **Appendix E.**

### 2.3.4 Network Communications Hookup

Every **NetScanner™ System** Intelligent Pressure Scanner contains a Host Port, allowing it to be interconnected in a network with other modules and a host computer. **Model 9116** has an Ethernet Host Port using TCP/IP and UDP/IP transmission protocols.

#### 2.3.4.1 Ethernet Host Port Hookup

The Ethernet Host port of every **Model 9116** Intelligent Pressure Scanner module, and its host computer, may be interconnected in a "star" network via a standard 10BaseT or 100BaseT, half or full duplex hub or switch. These standard devices will have their own power requirements. Hubs will treat the host computer connection and all **NetScanner™ System** module connections alike. Switches may provide, or negotiate different speeds and/or different handshaking on its various ports. The **Model 9116** will auto-negotiate through the hub or with the switch, for a half or full duplex connection at 10BaseT or 100BaseT speeds, establishing the best connection available. Ethernet communications pin assignments for the **Model 9116** electrical connector are shown in **Figure 2.2.** See **Figure 2.3** for typical network topology.

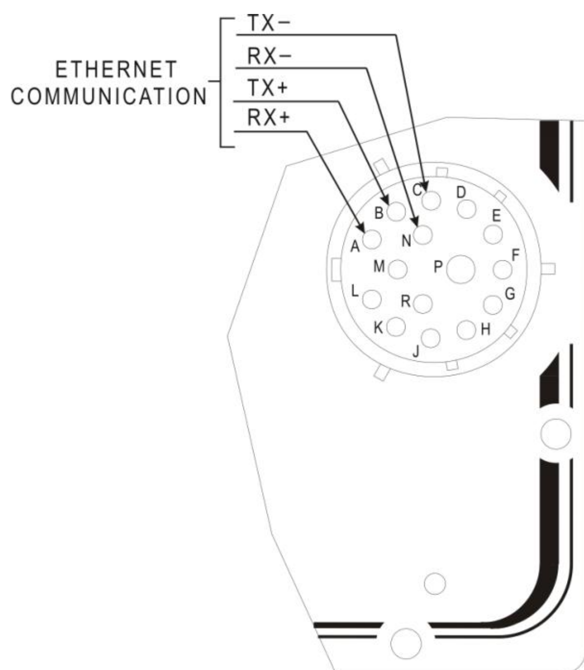



**Figure 2.2**
**Ethernet Host Port Connector Pins**

The host and each module must have a unique *Ethernet Hardware Address* (*a.k.a. MAC Address)* and a unique *IP Address*. The Ethernet Hardware address is generally fixed (at manufacturing time of the Ethernet microprocessor board inside the module). The Ethernet Hardware address is shown on each module's label. The Ethernet Intelligent Pressure Scanners are capable of supporting various methods for IP address assignment, using either the factory default (static IP addressing) or user-configured Static IP addressing or Dynamic IP address assignment. Dynamic IP address assignment is through the use of RARP or BOOTP protocols. *Unless your application requires the use of Dynamic IP address assignments, it is strongly suggested that the module be left configured for the Static IP address protocol.* **This default method is typically the simplest method for using the Intelligent Pressure Scanner.**

In the Static IP addressing mode, the module will use a factory default IP address on power-up. This default address is set to 200.20x.yyy.zzz where x is derived from the module type (0 for **Model 9116** and 1 for 9021/9022) and yyy.zzz is derived from the module serial number. A similar method is used to calculate each module's Ethernet hardware address shown on the module tag. Note that each of these fields (separated by a period, '.') is a decimal representation of a byte value. This means that each field may have a maximum value of 255. For **Model 9116** modules, the default IP address will be 200.200.y.zzz where y and zzz are calculated as follows:

y is the integer result of dividing the module serial number by 256.
zzz is the remainder of dividing the serial number by 256 (serial number modulus 256).

These calculations may be verified by checking that y * 256 + zzz equals the original module serial number. Once a module has powered-up and has assigned itself a default IP address, it is capable of communications.

An alternate method for assigning an IP address to an Ethernet module is referred to as a Dynamic IP assignment. This method allows a module to have its IP address dynamically assigned at power-up by an application running on a node of the TCP/IP or UDP/IP network. When configured for Dynamic IP address assignment protocols, the reset module will broadcast its Ethernet hardware (MAC) address on the network in a Dynamic IP request packet. This broadcast packet identifies the module by its hardware address and requests that a dynamic IP server application return to it an IP address for use. Once this broadcast message is received, the dynamic server application will then return an IP address to the module in a dynamic IP reply packet. Most dynamic IP server applications determine this IP address from a user maintained file that lists Ethernet hardware addresses with their desired IP address. If modules are added to the network or module IP addresses are to be changed, the user can simply edit this configuration file. This capability is common on most UNIX based machines and is also available (although less common) in some TCP/IP packages available for PC platforms.

Support of the Dynamic IP server protocol is not currently included in the Windows® 95/98/XP or Windows® NT operating systems. In order to allow users of PC platforms to make use of the Dynamic IP capabilities of the **Model 9116**, a simple Windows® 95/98/XP/NT application capable of acting as a Dynamic IP server. This application is referred to as ***BOOTP Lite*** since it actually makes use of the BOOTP protocol that closely resembles the Dynamic IP request. Like traditional dynamic IP servers, this application allows the user to configure a file that contains Ethernet hardware addresses and the corresponding IP address to assign to those devices. This application is free of charge and capable of running as a background program on Windows® 95/98 and NT machines. It may be downloaded from the MEAS home page, www.meas-spec.com.

Use of Static or Dynamic IP settings may be selected through the ***Set Operating Options*** ('w') command. If you are unsure how your module is configured, check the **Tx** LED during module power-up. If it begins to blink periodically after the module power-up, your instrument is configured for the Dynamic IP assignment protocol. (**Tx** LED remains **OFF** in static IP configuration.) If configured for Dynamic IP assignment, a dynamic server must be configured on the network to return an IP address to the module. Without an IP address, the host will be unable to open a TCP/IP or UDP/IP connection to the module.

| Note | **Obtaining the maximum performance of an Ethernet network is a complex process, involving many tradeoffs and is best performed by IT professionals or other personnel familiar with Ethernet parameters, topologies, and equipment capabilities. See the Measurement Specialties Website (www.meas-spec.com) for application notes and characteristics of the Model 9116 together with some hints for its use in high-speed, high-volume Ethernet networks.** |
|---|---|

| Note | **After closing the TCP/IP connection to the Model 9116, the host must wait 10 seconds before re-connecting.** |
|---|---|

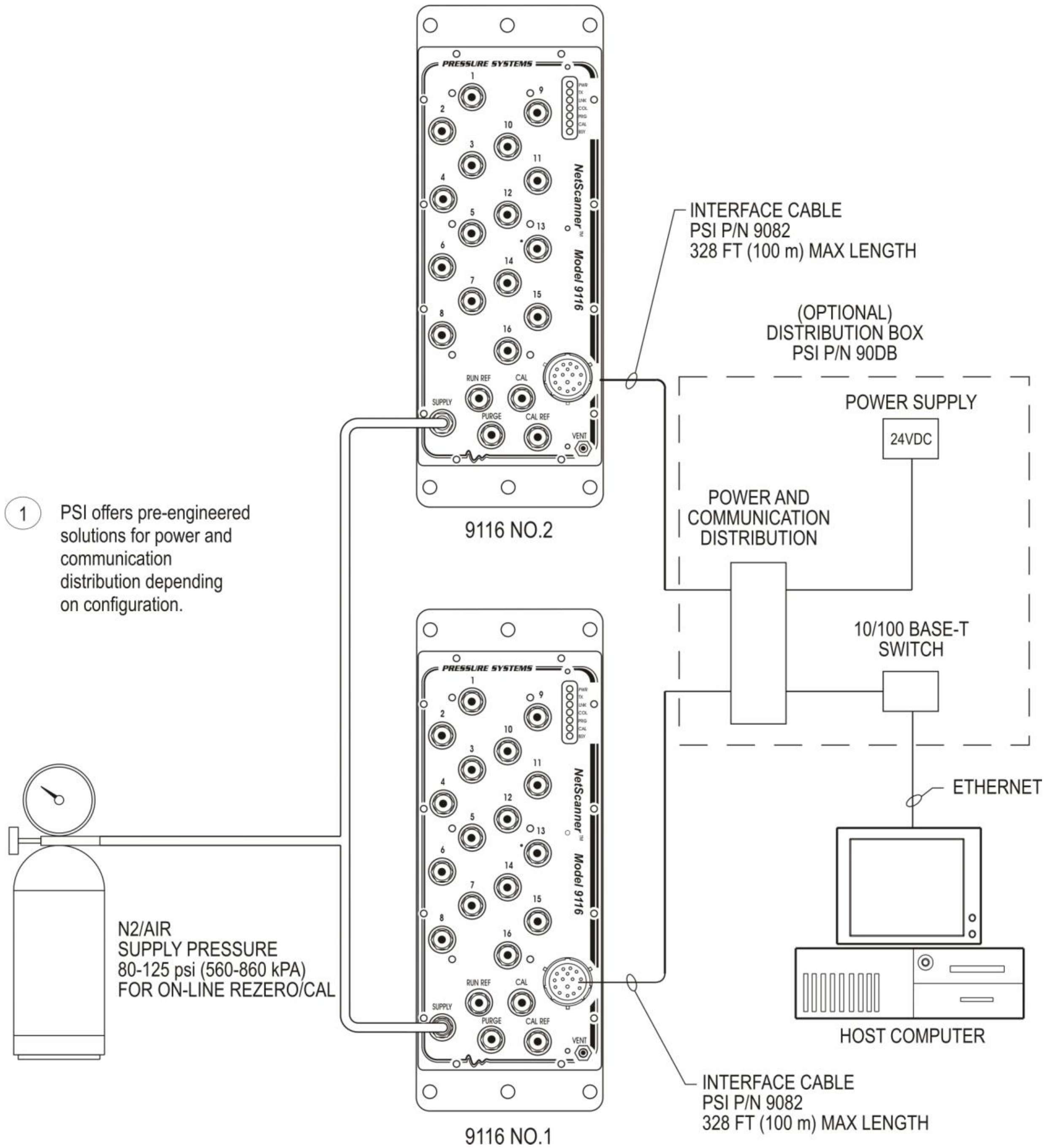


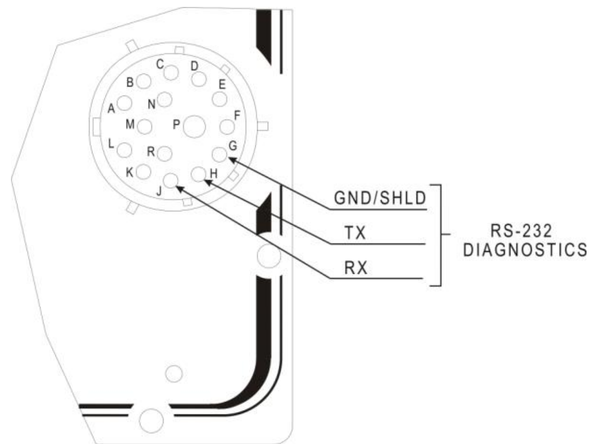

**Figure 2.3**
**Ethernet Network Topology**

### 2.3.5 Diagnostic Port Hookup

Each **NetScanner™ System** module contains a Diagnostic Port that supports diagnostic and operational functions. The Diagnostic Port has only a simple RS-232 asynchronous serial interface. The connections are made via certain pins of its common circular connector. Cable connection should be made according to **Table 2.1**.

**Table 2.1**
**Diagnostic Port Wiring**

| NetScanner™ System Diagnostic Port Connector |
|---|
| GND |
| Tx |
| Rx |




The RS-232 interface is capable of supporting simple asynchronous communications with fixed parameters of 9600 baud, no parity, 8 data bits, and 1 stop bit. Only communication cable lengths less than 30 feet (10 m) are recommended.

The **Model 9116** uses the diagnostic interface for optional configuration and diagnostic purposes only. The diagnostic port functions on the **Model 9116** is generally not required by the end user. Standard cables for this module do not include diagnostic port connections.

### 2.3.6 Pressure Connections

All pneumatic connections to **Model 9116** are found on the instrument top panel. The function of each input port is clearly engraved or printed next to each input. Connections are through bulge tubing, compression fittings, or special user-supplied fittings on the tubing plate. All pneumatic inputs to the **Model 9116** should contain only dry, non-corrosive gas.

All **Model 9116** standard Intelligent Pressure Scanners are supplied with the purge/leak check calibration manifold. Through software commands, this valve may be placed in one of four positions; **RUN**, **CAL**, **PURGE**, or **LEAK-CHARGE**. Pneumatic input requirements for these four operating positions are described in the following sections.

The following guidelines should be used when installing pressure connections to the **Model 9116** Intelligent Pressure Scanner modules.

- **Always wear safety glasses when working with pressurized lines.**
- **Ensure that user input pressure will not exceed the proof pressure ratings of the corresponding instrument transducer. Applying excessive pressure to measurement inputs can permanently damage the pressure transducers.**
- **Ensure that all tubing material is rated for the expected pressure and environmental conditions. Failure to use the proper tubing material may result in ruptured lines and possible personal injury.**
- **Ensure all high pressure lines are properly secured.**
- **Place retaining springs over all bulge tube fittings to ensure pneumatic lines remain attached and leak free. Springs should be pushed down on connections so that half of the spring length extends past the tube bulge.**

**Warning: Introduction of contaminants or corrosive materials to the module pneumatic inputs may damage module transducers, manifolds, and O-ring seals.**

### 2.3.6.1 RUN Mode Inputs

The standard pneumatic tubing plate for the **Model 9116** contains sixteen numbered pneumatic input channels. These numbered inputs are attached to corresponding pressure transducers inside the instrument and should be pneumatically attached to the pressure measurement points under test.

The standard tubing plate also contains an input labeled **RUN REF**. The **RUN REF** input is pneumatically connected to the reference side of all internal DH200 pressure transducers. The **RUN REF** connection is used for situations where all channels have one reference pressure. The reference pressure may be as high as 250 PSI (1720 kPa). See the **Model 9116** Data Sheet for detailed specifications. This input may also be left unattached to provide atmospheric reference pressure.

When using instruments with the reference per channel option (true differential), two pneumatic inputs will be provided for every numbered channel. These inputs are labeled '**P**' and '**R**'. The '**P**' connection is the test pressure input. The '**R**' connection is the transducer reference input pressure. Since each channel has its own reference pressure input, the **RUN REF** input is not provided on the true differential tubing plate.

#### 2.3.6.2 CAL Mode Inputs

The **Model 9116** tubing plates contain inputs labeled **CAL** and **CAL REF**. When the module's internal calibration valve is placed in the **CAL/RE-ZERO** position, all DH200 transducer pressure inputs are pneumatically connected to the **CAL** input port. All DH200 reference inputs are pneumatically connected to the **CAL REF** input port. The **CAL** input may be used to perform on-line zero adjustment of the transducers. The **CAL** input may also be used for DH200 span adjustment calibrations and accuracy tests if appropriate pressure calibrators (such as the 903x series) are available. Span calibration of multi-range scanners may also utilize the **CAL** port if the highest applied pressure does not exceed the proof pressure rating of any other installed transducer, otherwise the individual transducers must be calibrated with the valve in the **RUN** position.

When the internal calibration valve is in the **CAL/RE-ZERO** position, the **RUN** inputs (**RUN REF** and numbered input ports) are pneumatically dead-ended to prevent migration of contaminants into the instrument.

#### 2.3.6.3 PURGE Mode Inputs

All standard **Model 9116s** contain a *purge/leak check option*. The purge option allows users to apply positive pressure to the **PURGE** input which will then be vented out of the user input ports, forcing contaminants (such as moisture) out of the pneumatic input lines. **Note that on common reference Model 9116 scanners, only the numbered input ports will be purged (RUN REF is not purged).** True differential **Model 9116** scanners will purge both the run and reference input ports for all channels. **The purge supply provided to the Model 9116 must always be a higher pressure than the highest pressure present on the input ports of the module. The purge supply must also be capable of maintaining proper purge pressure at the high flow rates encountered while the module is in the purge mode.**

> **Warning: Failure to provide proper purge supply pressure will result in migration of moisture and contaminants into the Model 9116 module which can result in permanent damage to module components.**

When commanded into the **PURGE** position, the purge input pressure will be connected to the numbered measurement input ports allowing for a flow of air away from the instrument. The purge cycle should be terminated by commanding the **Model 9116** into a non-purge mode such as CAL. **Purge cycles should never be terminated by turning off the purge supply air while in the purge position.**

#### 2.3.6.4 LEAK Mode Inputs

The purge/leak charge valve design includes a leak check feature capable of testing the integrity of user pneumatic connections as well as those within the **Model 9116** module. For the leak mode to be used, all **RUN** mode pressure inputs must be dead ended (closed) by the user. When the **Model 9116** is commanded into the **LEAK-CHARGE** position, the **CAL** input port will be pneumatically connected to module run side inputs. Common reference modules will connect only the numbered run side inputs to **CAL** (**RUN REF** is not charged). True differential (reference per port) modules will connect both the measurement input and reference port to **CAL**. While in the **LEAK-CHARGE** position, a test pressure may be applied through the **CAL** port which will charge the dead ended run side tubulation.

**Note**

**Test pressures applied to the CAL port during the leak check operation must not exceed the full scale pressure of any internal transducers.**

Once the lines are charged, the **Model 9116** may be commanded back to the **RUN** position. This will reattach the charged run side lines to their corresponding internal transducer. Consecutive pressure readings from the **Model 9116** will now allow user calculation of the line leak rates. Once returned to the **RUN** position, lack of a pressure indicates a gross leak. A slowly declining pressure indicates a slight leak. A leak is more difficult to detect as tubing volume increases. In the case of true differential units where both sides of the sensor are pressurized with the leak test pressure, an initial differential pressure of 0.0 psi should be measured when the unit is placed in the **RUN** position. If the measurement or **RUN** side of the channel leaks at a rate greater than the reference side, a resulting negative differential pressure will be measured. Likewise, if the reference port tubing leaks at a rate greater than the measurement side, a resulting positive differential pressure will be measured.

#### 2.3.6.5 Supply Air

The **Model 9116** modules require an 80 psig minimum dry air (or inert gas) supply which is used to shift the internal calibration valve between its different positions. Each module contains a fitting marked “**SUPPLY**” for this input. Internal solenoid valves direct this supply pressure to the proper control port on the calibration valve as required by instrument commands. The absence of sufficient supply air to the module will prevent the calibration valve from shifting into requested positions (i.e., **RUN**, **CAL**, **PURGE**, **LEAK-CHARGE**).

**WARNING! Supply air should not exceed 125 psi (875 kPa). Excessive pressure may damage the internal solenoids.**

### 2.3.7 Case Grounding

The **Model 9116** module contains a case bypass capacitor which allows the module case to be mounted on hardware with a small common mode line voltage (less than 20 Volts).

### 2.3.8 Trigger Input Signal

**Model 9116** supports the use of a data acquisition synchronization signal, sometimes called “Hardware Trigger.” When configured through the ***Define/Control Host Stream*** **(‘c’)** command, the trigger signal can be used to initiate and synchronize data acquisition and stream outputs to the host.

The trigger signal is intended to be a 2-wire differential signal brought in through the **Model 9116** main electrical connector. The signal may be driven by a standard TTL compatible device. The switching threshold for this signal is set at 2.5 VDC.

### 2.3.9 Power Up Checks and Self-Diagnostics

Upon power-up of the module, the internal firmware will perform a number of self-diagnostic checks. The results of these tests are reflected by the ‘**OK**’ LED on the top panel. The **Model 9116** module completes the power up and self diagnostic.

See **Chapter 6, Troubleshooting Guide** for additional information and potential problem areas during the power-up sequence.

# Chapter 3

# Programming and Operation

## 3.1 Commands & Responses

### 3.1.1 Introduction

This chapter describes all *commands* a host computer program may send to a **Model 9116** Intelligent Pressure Scanner module, as well as the data or status *responses* returned by the module. Most applications require a working knowledge of only a small number of these commands.

**Model 9116** has an Ethernet interface, and uses layered TCP/IP or UDP/IP transmission protocols to communicate with a host computer. All commands/responses to/from **Model 9116** modules are embedded in the data fields of either a TCP or UDP packet header. In turn, these packets are themselves embedded in the data field of an IP packet header, which is embedded in the data field of an Ethernet packet header. Thus, the term *layered* protocols.

#### 3.1.1.1 TCP/UDP/IP Protocols

Both TCP/IP and UDP/IP protocols are a well-established set of rules for communicating over a network (LAN, intranet, or internet), and are independent of the network's physical medium. All the modules use the TCP/IP protocols for most commands and responses since the TCP layer provides a robust error detection and correction mechanism. TCP/IP requires a formal connection be established between host and module. The simpler UDP layer, requiring no formal connection, is utilized for a subset of commands and query responses.

Using the underlying basic IP protocol, the host computer and interconnected modules are all "peers" that can communicate equally. Each "peer" must have its own unique "logical" *IP Address* (as well as its own unique "physical" *Ethernet Address*) to be directly addressed. Any "peer" may initiate transmissions without permission from the receiver. In the **NetScanner™ System** implementation, the host computer is normally a *client* and generally initiates most transmissions by sending commands to the modules, which are normally *servers*. However, a module can initiate its own transmissions in some operating modes (e.g., the *hardware-triggered* or *free-run* autonomous *host streams* generated by the ***Configure/Control Autonomous Host Streams*** (**'c'**) command).

A "peer" may be directly addressed by its *IP address (in xxx.xxx.xxx.xxx format)*, or by use of a predefined *logical name* that allows its *IP Address* to be looked-up in the sender's database or in a central network server's database. The Windows® 95/98/XP/NT operating systems provide a simple text file database called "Hosts." Review the file "Hosts.sam" in the "C:\windows" directory. Modify and rename it "Hosts." (no file extension) to activate it.

Before the host computer and any module can communicate with the higher level TCP/IP protocols, the host (*client*) must request a *connection* be established with the module (*server*). Each module expects all such requests for *connection* to be requested by its *IP Address*, and

directed to "well-known" port 9000 (default). After the connection is made, a *socket* is established as a logical handle to this connection. The host and module may then communicate, via this *socket,* until it is closed or is lost at either module or host end, due to power failure or reboot). The host and module may also communicate in a limited fashion *without a connection*, using the middle-level UDP/IP protocols. In that case, the host simply broadcasts commands via port 7000, and each module (that chooses to respond) returns the response on port 7001. Only a few commands use UDP/IP in **Model 9116** modules.

## 3.1.2 Commands

The commands (and responses) used by **Model 9116** modules consist of short strings of ASCII characters. The TCP/IP and UDP/IP protocols allow for the transfer of either printable ASCII characters or binary data. When using certain formats, internal binary data values are often converted to ASCII-hex digit strings externally. Such values may include the ASCII number characters '0' through '9,' the *uppercase* ASCII characters 'A' through 'F,' and the *lowercase* letters 'a' through 'f'.' These hex values may represent bit maps of individual options, or actual integer or floating point (IEEE) binary data values. In other cases (see optional *format 7* below) binary data may be transmitted directly as 4-byte (32-bit) binary values without any formatting change. Such binary transmissions use big-endian (default) byte ordering but may be commanded to use little-endian for some data.

### 3.1.2.1 General Command Format

A typical TCP/IP command (contained in the data field following a TCP packet header) is a variable-length character string with the following general fields:

- a 1-character *command letter (c)*.
- an optional *position* field *(pppp)*, a variable length string of hexadecimal digits.
- a variable number of optional *datum* fields *( dddd)*: each a variable length string, *normally* formatted as a decimal number (with a leading *space* character, and with or without *sign* and/or *decimal point*, as needed).

Using brackets ( [ ] ) to show optional elements, and ellipsis ( ...) to show indefinite repetition, a typical TCP/IP command may be viewed schematically as follows:

"c[[[[*p*]*p*]*p*]*p*][ *dddd*][ *dddd*]...]"

From this schematic, it should be clear that the *command letter* (c) is required, the *position* field (*pppp*) immediately follows it, and may have 0, 1, 2, 3, or 4 characters, and there may be zero or more *datum* fields ( *dddd*), as required. For simplicity, the variable length nature of each " *dddd*" string is not shown [with brackets] above, but the required leading space character is shown. The *position* field is similarly simplified (as "*pppp*") below.

A typical UDP/IP command (contained in the data field following a UDP packet header) is also a variable length character string, but has a simpler format. Generally, it has a variable length *command string* (*cccccc*), followed by one optional *datum* ( *dddd*) field (preceded by one *space* character):

"*cccccc*[ *dddd*]"

Since there are only a few simple UDP/IP commands, all references to *commands* below should assume TCP/IP commands, unless otherwise indicated.

#### 3.1.2.2 Command Field

All **Model 9116** scanners recognize a set of predefined commands. Most are TCP/IP commands, having only a single alphabetic letter for a *command* field. These are recognized only when a formal *socket* connection is established with the host computer. A few are UDP/IP commands with a longer *command* field. These are recognized any time the module has power applied. All commands are functionally summarized in the following sections and detailed in reference **Section 3.2**.

#### 3.1.2.3 Position Field

The **Model 9116** Intelligent Pressure Scanner may contain up to sixteen (16) separate input/output channels. When commands affect *certain channels* scanned by the module, the *position* field is used to identify those channels as bits in a bit map. If a channel's corresponding bit in the *position* field is set to a one (1), then that channel is affected by the command. The least-significant (rightmost) bit 0 corresponds to Channel 1, and the most-significant (leftmost) bit 15 corresponds to Channel 16. Since neither model has more than sixteen (16) channels, the *position field* will usually be 16-bits, represented by four (4) ASCII-hex characters in the command. For example, only Channels 16 and 1 are selected below in this 16-bit (4-character) position field:

| Bit# | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chan# | **16** | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | **1** |
| Binary | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Hex | 8 | | | | 0 | | | | 0 | | | | 1 | | | |

The above *position field*, with *all* applicable bits set (i.e., FFFF for 16-channel module), specifies *all channels*. However, a module-independent variation allows a *missing position field* to designate *all channels* — but only when there are no other parameters following the *position field* in the command. For such commands, the hex *position field* may be reduced to 3, 2, or 1 characters when no channel bits need be set (1) in the discarded high-order characters (nibbles).

Note

**The channel data requested will always be returned in order of highest requested channel to lowest requested channel.**

#### 3.1.2.4 Datum Fields

Any *datum* fields in a command generally contain data to be sent to the module, usually specified by a *position* field bit map. In some commands (when data are received from a module instead) no datum fields are required in the command itself but the *position* field bit map is still used to specify the order that data are returned in the command's response. In either case, the order bits are set (to 1) in the *position* field bit map (highest channel # to lowest channel#, left to right) is the order these datum fields are received or sent.

Each *datum* field may be variable in length, whether part of the command itself or the command's response. In its most common format, a *datum* begins with a *space* character (' '), and is followed by an optional sign, decimal digits, and a decimal point, as needed (e.g., ' -*vv.vvvvvv*'). For other formats it may be a hex digit string or pure binary number.

#### 3.1.2.5 Format Field

Some commands, that either send data to a module (as command parameters), or cause the host to receive data (via command's response), have an extra *format* parameter *(f* digit) appended to (or specified in) the *position* field. This parameter, when specified (or implied by default), governs how internal data are converted to/from external (user-visible) form.

- The most common format (*f=0)* causes each datum (in command or response) to be represented as printable ASCII numbers externally (with optional *sign* and *decimal point* as needed). Internally, the module sets/obtains each converted datum to/from a single precision binary (32-bit) IEEE float

- Some formats (*f*=1, 2, 5) encode/decode the internal binary format to/from ASCII hexadecimal external form. Some of these "hex dump" formats provide an external hex bit map of the internal binary value (float or integer as appropriate). Format 5 may encode/decode the internal float value to/from an *intermediate* scaled binary integer (e.g., float value * 1000 into integer, then to/from a hex bit map).

- Two special "binary dump" formats (*f*=7 and *f*=8) may be used by some commands to accept/return binary data directly from/to the user's command/response. Such values are not user-readable in their external form, but are directly machine readable and provide highly compact storage without any accuracy loss due to formatting. Use of these formats allows both the module and host program to operate in their most efficient, low overhead mode. Format 7 returns the most significant byte first (i.e., *big endian*). Format 8 returns the least significant byte first (i.e., *little endian*).

See the individual command descriptions for the formats a particular command recognizes.

### 3.1.3 Responses

Four (4) types of responses can be returned from a **Model 9116** Intelligent Pressure Scanner module:

- an ***Error*** response,
- an ***Acknowledge*** response,
- an ***Acknowledge with Data*** response, or
- a Network Query response.

The first three may be returned by TCP/IP commands, the latter from a UDP/IP command.

The error response consists of the letter 'N' (for NAK, or negative acknowledge), followed by a 2-digit hexadecimal error code. The following table lists the error codes that can be returned from a **Model 9116** module:

**Table 3.1**
**Error Codes**

| CODE | MEANING |
|---|---|
| 00 | (Unused) |
| 01 | Undefined Command Received |
| 02 | Unused by TCP/IP |
| 03 | Input Buffer Overrun |
| 04 | Invalid ASCII Character Received |
| 05 | Data Field Error |
| 06 | Unused by TCP/IP |
| 07 | Specified Limits Invalid |
| 08 | NetScanner error; invalid parameter |
| 09 | Insufficient source air to shift calibration valve |
| 0A | Calibration valve not in requested position |

The *Acknowledge* response is returned from a module when a command is received that requires no data to be returned, and no error is detected. It indicates successful parsing and execution of the last received command. It consists of the letter 'A' (for ACK, or acknowledge).

The *Acknowledge with Data* response is returned when a module receives a command requesting data. **Model 9116** modules will typically return only the requested data values, each preceded by a space character (except for format 7). No **'A'** acknowledge letter begins this data response. **Data are returned for the highest requested channel number first**.

#### 3.1.3.1 Interpreting Offset Values (Re-zero Calibration Adjustment)

When a module is instructed to execute the command ***Calculate and Set Offsets*** (**'h'**), a datum corresponding to the calculated ***offset correction*** term (or coefficient) is returned for each affected channel. Each such coefficient value is stored internally, and will be subtracted in all subsequently calculated data conversions, to correct for zero drift effects. The command only returns them in the response (in current engineering units (EU) of pressure) to allow the user to make reasonableness checks on them. The ***Read Internal Coefficients*** (**'u'**) command will return them on demand.

#### 3.1.3.2 Interpreting Gain Values (Span Calibration Adjustment)

When a module is instructed to execute the command ***Calculate and Set Gains*** (**'Z'**), a datum corresponding to the calculated ***gain correction*** term (or coefficient) is returned for each affected channel. Like the *offset* coefficient, each *gain* coefficient is stored internally, and will be used in all subsequently calculated data conversions, to correct for gain change effects. The command returns them in the response (as a unitless scale factor near 1.0) to allow the user to make reasonableness checks on them. The ***Read Internal Coefficients*** (**'u'**) command will return them on demand.

#### 3.1.3.3 Interpreting Engineering Units Output

All modules perform all internal pressure calculations in engineering units of pounds per square inch (psi). By default, all pressure data in responses and command parameters will also be in psi. A different engineering unit (e.g., kPa) may be obtained by changing an internal **EU Pressure Conversion Scaler** (normally 1.0). See the "***Read/Download Internal Coefficients***" **('u'/'v')** commands (array 11, coefficient 01). Change this default multiplier value (1.0) to obtain units other than psi.

### 3.1.4 Functional Command Overview

The various commands for **Model 9116** modules are best introduced by classifying them into functional groups and then describing how each function is carried out in a typical system. The following functions are defined for this purpose:

- Start-up Initialization
- Scan List Definition for Acquisition
- Calibration Adjustment of Engineering Unit *Correction* Coefficients
- Acquisition/Delivery of Data to Host
- Network Query and Control

Please look ahead to **Table 3.1**, labeled ***Model 9116 Intelligent Pressure Scanner Commands***, in **Section 3.2**, for a quick-look summary of all commands available to the **Model 9116** modules. Each command may be referenced by both its *functional title* and by its *command id* in the functional discussion sub-sections below.

The ***Detailed Command Description Reference*** immediately follows the table in **Section 3.2**, with each command description occupying a page (or more if necessary). Command descriptions in this section (as in the table) are ordered first by *type* (TCP/IP then UDP/IP), then by *"command id"* in *ASCII order* (*UPPERCASE* letters (***A .. Z***) first, then *lowercase* letters (***a .. z***)) .

### 3.1.4.1 Startup Initialization

Since power supplies may be distributed widely across a network of modules and host computer(s), it is not uncommon for modules (singly or together) and the host to lose power independently. Thus, their power may be restored at different times. Startup initialization, for every module, must normally be performed when its power is restored, as each module enters default states after power-up, which may not be the state the host computer had previously been operating in. Any previous TCP/IP socket connection is also lost after power failure and must be re-established between host and module before any TCP/IP commands can be recognized by the module. These commands are generally used to detect that startup initialization has occurred (or to force reset at other times), after which other commands may be used to restore the original operating condition.

With **Model 9116** modules, the ***Power-Up Clear*** (**'A'**) command is used as a simple command to elicit a known response from a module. Although this causes no internal function within the module, it will result in an acknowledgment being returned to the host computer to verify proper communications. The best way to detect that a power reset has occurred in a module is to notice that the TCP/IP socket connection is no longer valid. At any point during module operation, the ***Reset*** (**'B'**) command may be used to return any module to its default "reset" state. If the module is then required to enter any other states (that were previously programmed for it by the host), the host must then restore these states accordingly using the appropriate commands. This reset command simply returns internal software parameters to a default state (as after power up or reboot). It will not close the existing TCP/IP socket (as will power up or reboot).

The ***Set/Do Operating Options/Functions*** (**'w'**) command has many purposes, but may first be utilized during the module initialization stage. It may also be executed at any time during data acquisition. However, some non-factory-default options of **'w'** may become the new reset default, if a particular function is used to establish them in non-volatile memory.

If any form of the ***Configure/Control Autonomous Host Streams*** **('c')** command or the ***Configure/Control Multi-Point Calibration*** (**'C'**) command was in use before reset, it must be executed again after the reset to restore it. Any other command, that establishes the module in a *non-default reset state,* must be re-executed after a reset, if processing is to continue in that state.

The ***Network Query*** ("psi9000") UDP/IP command may be used (at any time) to make each module on the network identify itself to the host(s). A parameter, returned in each module's response, indicates whether or not a module still has a valid connection. This is a useful way to detect if an overt *reset* occurs in a module. The module may be configured to emit this response *automatically* after any reset (power on or reboot).

### 3.1.4.2 Module Data Acquisition

After power-up, all modules will begin to scan all attached transducer channels in channel number order. Scanning will occur at the module's maximum internal rate (using the previously stored *number of data averages per channel*). The data are stored in an internal buffer, available for retrieval by the host computer. Engineering units conversion of the scanned channels is accomplished using thermal correction data extracted from each transducer at power-up. While scanning, the module will automatically monitor the attached transducer's temperature, correcting engineering unit output for any temperature effects.

All modules effectively defer the host computer's decision of "which channels of data do I want" until that time when the host chooses to send read commands to actually retrieve the desired data from the latest "buffered copy" of the continuously scanned, averaged, and engineering-unit-converted data.

See **Section 3.1.4.4** (**Delivery of Acquired Data to Host**) for more information.

While scanning, all modules take multiple samples and average each channel. The *number of samples per scanned channel* defaults to 8, but may be set to one (to disable averaging) or to any power of 2 (1, 2, 4, 8, 16, 32) to change the degree of averaging (and its effect on maximum scan rate). The ***Set Operating Options*** (**'w'**) command may change this variable at any time.

#### 3.1.4.3 Calibration Adjustment of Offset/Gain Correction Coefficients

All **Model 9116** Intelligent Pressure Scanners have built in software commands (and pneumatic hardware) to perform a periodic *zero* and *span* calibration adjustment of attached pressure transducers. Use of these periodic adjustments result in the highest possible data accuracy. The result of these calibrations are a new set of internal *offset* and *gain* coefficients. These *correction* coefficients are over and above those factory-determined and *unchanging* thermal correction coefficients stored in each transducer's non-volatile memory. The factory coefficients provide the basic engineering unit conversion capability, while also correcting for various non-linear effects, including temperature effect compensation. The *offset* and *gain* correction coefficients provide for fine linear fit adjustment of the factory calibration of each transducer. **If used properly, the periodic zero and span calibration adjustment should be the only calibration required to maintain specified performance through the life of the Intelligent Pressure Scanner.**

It is generally necessary for the transducer to have real *zero* and *span* pressure (specified as 2 or more values) applied when calibration adjustment is required. These pressure values may be generated by secondary pressure standards, such as the model 903x calibrator module or by other external means provided by the customer (such as a dead weight calibrator). For the more common zero-only calibration adjustment, zero differential pressures can typically be provided without the need for external pressure generators. All **Model 9116** modules have built-in pneumatic inputs (CAL side inputs) and calibration manifolds required for directing the generated pressures to the various channels of the module(s) being calibrated. **Refer to Chapter 4 of this manual for detailed background and procedures for periodic calibration of the Intelligent Pressure Scanners.** A summary of the commands used for calibration purposes is included below.

The ***Calculate and Set Offsets*** (**'h'**) command is executed only when a suitable "minimum" (e.g., zero) pressure has been applied to all channels of the module. The new *offset* coefficients that result from execution of this command are stored in the module's volatile (or temporary) engineering-unit conversion database. They are also returned to the host in the command's response.

The ***Calculate and Set Gains*** (**'Z'**) command should be executed only when "full-scale" (or other suitable specified up-scale) pressure has been applied to the appropriate channels of a module. The new *gain* coefficients that result from this command are stored in the module's volatile (or temporary) engineering-unit conversion database. They are also returned to the host in the command's response.

The ***Configure/Control Multi-Point Calibration*** (**'C'**) command, actually 4 sub-commands, is an improvement over the single calibration commands (**'h'** and **'Z'**) described above. Though **'C'** provides for the *adjustment* of the same *offset* and *gain* correction coefficients already described above, it does so with two **or more** applied pressure calibration points. The final linear fit (i.e., new *offset* and *gain* correction coefficients) is a "least squares" correction fit between all the calibration points specified. This **'C'** command is particularly useful in calibrating differential transducers over their entire negative-to-positive range.

Although the calculated *offset* and *gain* correction coefficients are kept in volatile memory following execution of the calibration commands, they may be stored in non-volatile transducer memory following the execution of the calibration commands (for use by all subsequent EU conversions). This is accomplished with the ***Set/Do Operating Options*** (**'w'**) command (Index 08 and 09).

The above correction coefficients are maintained internally in IEEE floating-point format. The ***Read Internal Coefficients*** (**'u'**) command and the ***Download Internal Coefficients*** (**'v'**) command can return (or manually set) calibration coefficients to the host in decimal or hex dump formats in their responses.

### 3.1.4.4 Delivery of Acquired Data To Host

Several commands apply to host delivery of acquired data, either *on demand* or *autonomously*. The ***Read High Precision Data*** (**'r'**) command may be used to obtain high precision data (selected channels in various formats). The modules also provide several high speed, high resolution output commands. The ***Read High-Speed Data*** (**'b'**) command is used to read "pure binary" engineering unit pressure (all channels in the lowest overhead format). Use the **'r'** and **'b'** commands to get acquired data *on demand*.

The module can also deliver EU *pressure* data in *streams,* which consist of TCP/IP or UDP/IP data packets that arrive *autonomously* in the host (with data from *selected* channels being delivered in various formats at various rates). Up to three independent *streams* may be configured, started, stopped, and cleared with the ***Define/Control Autonomous Host Streams*** (**'c'**) command. In conjunction with *hardware triggering*, this *autonomous* delivery method can also make the module *acquire* (as well as deliver) data in its most efficient and time-synchronized manner. This also frees the host to receive, process, or record these data in its most efficient manner, since it need not waste time continually requesting new data with commands.

The modules also have special purpose *on demand* data acquisition commands, including: ***Read Transducer Voltages*** (**'V'**) and ***Read Transducer Raw A/D Counts*** (**'a'**), which provide two views of raw *pressure* data. It has similar commands providing EU temperature (□C) and other raw views of each channel's special *temperature* signal, including ***Read Transducer Temperatures*** (**'t'**), ***Read Temperature A/D Counts*** (**'m'**), and ***Read Temperature Voltages*** (**'n'**). This command group is generally used for diagnostic purposes. All of these special purpose data (plus other module status information) may also be periodically delivered to the host automatically in any of the three flexible *autonomous streams* configured by the **'c'** command.

#### 3.1.4.5 Network Query and Control Functions

A special subset of three (3) UDP/IP commands may be sent to a module at any time power is applied to it (i.e., neither a host socket connection nor a unique IP Address assignment is required). Each such command is *broadcast* to all modules (i.e., sent to IP Address 255.255.255.255) via Port 7000, and any module wishing to respond will return a UDP/IP broadcast response via Port 7001.

Only one of these commands returns a response. This is the ***Network Query*** **("psi9000")** command. The others cause the module to be re-booted, therefore no response is possible. One command changes the way the module gets its IP address assignment (i.e., dynamically from a server or statically from factory-set internal data).

#### 3.1.4.6 Other Functions

Some commands may be used at any time to obtain information about the internal setup and status of a module. The ***Read Module Status*** (**'q'**) command is an example. Also, the ***Set/Do Operating Options*** (**'w'**) command, though generally used after power-up reset, may also be used at other times to change system operation. The actual *feedback position status* of internal *valves*, and several *temperature status* conditions may be configured to be periodically delivered to the host automatically in any of the three *autonomous streams* configured by the **'c'** command.

# 3.2 Detailed Command Description Reference

All commands applicable to the **Model 9116** Intelligent Pressure Scanner modules are described on the following pages. They are summarized in the following table. For convenience, this table is also repeated in **Appendix B**.

| TYPE | COMMAND ID | COMMAND FUNCTIONS |
|---|---|---|
| TCP/IP Commands | A | Power-Up Clear |
| | B | Reset |
| | C | Configure/Control Multi-Point Calibration (4 sub-commands) |
| | V | Read Transducer Voltages |
| | Z | Calculate and Set Gains (Span Cal) |
| | a | Read Transducer Raw A/D Counts |
| | b | Acquire High Speed Data |
| | c | Define/Control Autonomous Host Streams (6 sub-commands) |
| | h | Calculate and Set Offsets (Re-zero Cal) |
| | m | Read Temperature A/D Counts |
| | n | Read Temperature Voltage |
| | q | Read Module Status |
| | r | Read High Precision Data |
| | t | Read Transducer Temperature |
| | u | Read Internal Coefficients |
| | v | Download Internal Coefficients |
| | w | Set/Do Operating Options/Functions |
| UDP/IP Commands | psi9000 | Query Network |
| | psireboot | Reboot Specified Module |
| | psirarp | Change Specified Module's IP Address Resolution Method (then Reboot) |

## POWER UP CLEAR (Command 'A')

**Purpose:** This command has no internal module affect. It is used as a simple method to verify proper communications to the **Model 9116** module.

| | |
|---|---|
| **Command** | **"A"**<br><br>'A' is the *command* letter. |
| **Response** | **"A"**<br><br>'A' is the *acknowledge* letter. |

**Description:** This command is generally used as a simple 'NOP' mechanism to verify proper communications with a module.

**Example:**

- Send TCP/IP command to a module (via its open socket) to acknowledge module power on:

  **"A"**

  Read following response:

  **"A"**

## RESET (Command 'B')

**Purpose:** Instructs the module to reset internal operating parameters, and to set all internal control variables to their default "reset" state (see description below). The current TCP/IP socket connection will remain open. Execution after a power off/on cycle is optional (unnecessary).

| | |
|---|---|
| **Command** | "**B**"<br><br>'B' is the *command* letter. |
| **Response** | **"A"**<br><br>'A' is the *acknowledge* letter. |

**Description:** The module returns to the following "reset" states if this command is executed:

- Re-zero correction (offset) terms are set to the last values stored in transducer memory.
- Span correction (gain) terms are set to the last values stored in transducer memory.
- Calibration Valve is set to the RUN Position
- Number of Samples for Data Averaging is set to last value stored in non-volatile memory (factory default = 8).
- Any *autonomous* host data delivery *streams* defined by **'c'** sub-commands are reset (undefined).
- The *Multi-Point Calibration* function defined by **'C'** sub-commands is reset (undefined) if in progress.

**Example:**

- Send TCP/IP command to a **Model 9116** module (via open socket) to reset defaults:

  "**B**"

  Read following response:

  "**A**"

## CONFIGURE/CONTROL MULTI-POINT CALIBRATION (Command 'C')

**Purpose:** This *command* is actually *four (4) sub-commands*. The *first* configures and starts a **Multi-Point Calibration** adjustment function for selected channels in the module. *Another* is repeated multiple times to collect data for each defined calibration point. *Another* ends the calibration function normally by calculating new *offset* and *gain* adjustment coefficients from the collected data. It then returns the module to its normal state, but with improved accuracy. A *final* sub-command is used only if it becomes necessary to *abort* the calibration function while in progress. The *general form* of all sub-commands is described in the table below. Subsequent pages separately describe *each individual sub-command* and give examples of each.

| | |
|---|---|
| **Command** | "**C *ii*[ *dddd*]...** "<br><br>'C' is the *command* letter.<br>' *ii*' is a required *sub-command* index preceded by a *space* character.<br>' *dddd*' are zero or more optional *datum* (or parameter) fields, each preceded by a *space* character. These vary with the sub-command used. |
| **Response** | Depends upon the particular sub-command (*ii*) used. |

**Description:** The four **'C'** sub-commands configure and control operation of a **Multi-Point Calibration** function that is similar to the simpler *re-zero* and *span* calibration adjustment functions (see separate **'h'** and **'Z'** commands). However, **'C'** adjusts **both** the *offset* and *gain* correction coefficients of each affected transducer at the same time, using two **or more** calibration points. Thus, instead of simply calculating a new linear (i.e., straight line) adjustment function that **passes through** the supplied *zero* and *span* calibration points, it calculates a *best-fit* straight line, using the ***least squares method,*** that **comes "as close as possible" to *all* the supplied calibration points**. This correction method provides the very best adjustment throughout the entire range (negative to positive) of a differential transducer.

**Note**

**Avoid confusing this Calibrate command 'C' (upper case C) with the *Configure/Control Autonomous Host Streams* command 'c' (lower case c). Like "c," but unlike most other module commands, all sub-commands of this command require a *space* between the *command id* ('C') and the first parameter (*ii*).**

## Command 'C'— Sub-command Index 00: *Configure & Start Multi-Point Calibration*

This sub-command has four (4) additional required parameters used to configure and start the Multi-Point Calibration function.

| | |
|---|---|
| **Command** | "**C 00 *pppp npts ord avg***"<br><br>'C' is the *command* letter.<br>' 00' is the *sub-command index* (*ii*) for *Configure & Start*.<br>' *pppp*' is a 1-4 hex digit *position* field (channel selection bit map), that selects any of the 1-16 (9116) *internal channels* to be affected by the multi-point calibration.<br>' *npts*' is the *number of unique calibration points* (between 1 and 19) to be supplied during the calibration function.<br>' *ord*' is the *order of the adjustment fit*, which currently must be 1 for a 1st order *linear fit* of the calibration data (i.e., a straight line).<br>' *avg*' is the *number of A/D data samples collected and averaged* for each calibration point supplied (must be a power of 2 in the set 2, 4, 8, 16, or 32)<br>**NOTE: all parameters are separated by a *space*.** |
| **Response** | "**A**"<br><br>'A' is the *acknowledge* letter and is returned if all parameters are supplied with reasonable values. Else, an error ('N') response is returned. |

**Description:** Configures and starts the **Multi-Point Calibration** function. It specifies the particular channels (*pppp*) whose *offset* and *span* adjustment coefficients will be replaced when the function is completed. All specified channels must have the **same full-scale pressure range**. Modules with more than one range of internal transducers installed must have channels from each range calibrated separately.

This sub-command immediately alters the module's normal data acquisition, processes *A/D samples for average* count (default = 8, or as per the 'w10dd' command), and uses the sub-command's *avg* parameter sample count instead. A larger count (e.g., 32) is encouraged for calibration purposes. The original sample count will not be restored until the calibration function ends or is aborted (per other sub-commands described on the following pages).

The *npts* parameter fixes how many calibration points must be supplied when the **Multi-Point Calibration** function's *data collection phase* starts later with multiple invocations of another sub-command (described below). Currently, only a linear (1st order) (' *ord=1*') fit of the calibration points is available.

**Example:**

- Configure and start the **Multi-Point Calibration** function so that it affects only the first four (4) channels of the module. Three (3) pressure calibration points will by supplied when we continue this function later (see example for '01' sub-command below). A linear (1st order) fit will be used to obtain a new set of *offset* and *gain* correction coefficients for these four (4) channels. The maximum average sample count (32) is used to collect each calibration data point, so as to minimize any noise in the data samples. The module's data acquisition process is altered immediately to collect the increased number of averages.

  "**C 00 F 3 1 32**"

  Read response:

  "**A**"

## Command 'C'— Sub-command Index 01: *Collect Data for a Calibration Point*

This sub-command has two (2) additional required parameters.

| | |
|---|---|
| **Command** | "**C 01** ***pnt pppp.pppp***"<br><br>'C' is the *command* letter.<br>' 01' is the *sub-command index* (*ii*) for *Collect Data*<br>' *pnt*' identifies a *particular calibration point* that will be supplied. It must be between 1 and *npts*, where *npts* was a parameter of the previously executed *Configure & Start* ('00') sub-command.<br>' *pppp.pppp*' is the *pressure* value (in current EU) that is actually applied currently to the module's transducers by a precision calibrator.<br><br>**NOTE: all parameters are separated by a *space*.** |
| **Response** | "**pppp.pppp [pppp.pppp]...**"<br><br>The actual *measured pressure values* (in current EU) from each affected channel of the module (highest numbered specified channel first, lowest numbered specified channel last, as per the *pppp* bit map parameter of the *Configure & Start* ('00') sub-command. The *decimal* response datum format (format 0) is always used. |

**Description:** This sub-command (to be executed two or more times) carries out the *data collection phase* of the **Multi-Point Calibration** function for exactly *one* (1) calibration point (i.e., per parameter *pnt*). Each execution applies a specified pressure value; then collects, averages, and stores the data for that calibration point. It must be repeated until all pressure points, as specified by the *npts* parameter of the original *Configure & Start* ('00') sub-command, are applied and their data collected. For each particular point, enter the sub-command after that point's *pressure value* has been properly applied to the module, and that value is stable (unchanging). Pressure may be applied to either the **Cal** or **Run** ports, as

necessary. Use a Model 903x Calibrator or some other suitable precision pressure source to generate the pressure.

It is not necessary to enter the two or more calibration points in strict numerical order (i.e., 1, 2, ... *npts*). Any convenient entry order is allowed, though each point's actual *pressure value* must be correctly stated (with the *pppp.pppp* parameter) when executed. Previously entered points may be reentered if it is necessary to account for hysteresis. However, all the points specified by the *pts* parameter of the *Configure & Start* ('00') sub-command must be supplied before the final *Calculate and Apply* ('02') sub-command can be executed, else an error will result.

**Example:**

- Supply each of the previously-specified three (3) pressure calibration points to the Multi-Point Calibration function, as was stated in the *previous example* of the *Configure and Start* ('00') sub-command. Assume that all the affected four (4) channels have differential transducers with the same -5 to +5 psi range. Include at least one pressure point in the negative range of these transducers

  "**C 01 1 -2.5**"
  "**C 01 2 0.0**"
  "**C 01 3 5.0**"

  Read responses (separately after each command executed above):

  "-2.4998 -2.4999 -2.5001 -2.500"
  "0.0 0.0013 -0.0133 -0.00001"
  "5.0091 4.9992 5.0010 4.9998"

  Data are returned in *reverse* channel number order (i.e., 4, 3, 2, 1) in each response.

## Command ‘C’- Sub-command Index 02: *Calculate & Apply Correction Coefficients*

This sub-command has no additional parameters.

| | |
|---|---|
| **Command** | “**C 02**”<br><br>‘C’ is the *command* letter.<br>‘02’ is the *sub-command index* (*ii*) for *Calculate & Apply*<br><br>**NOTE: all parameters are separated by a *space*.** |
| **Response** | “**A**”<br><br>‘A’ is the *acknowledge* letter — returned if the required number of calibration data points had their data successfully collected previously, and the resulting calculated data is reasonable.  Else, an error (‘N’) response is returned. |

**Description:** This sub-command finishes the **Multi-Point Calibration** function, previously started by the *Configure & Start* (‘00’) sub-command.  It calculates new correction coefficients using the pressure data collected by all required executions of the *Collect Data* (‘01’) sub-command.

All the averaged data points collected previously are checked for reasonableness, and then a new set of *zero* and *gain* correction coefficients are calculated by the *least-squares* method for each channel (transducer) affected by the calibration.  These are stored in the module’s volatile memory for use by all subsequent EU data conversion of these channels until the module is *reset* or *powered off*.  These coefficients may be stored in the non-volatile memory of the module’s transducers with the **‘w’** command (see indexes 08 and 09 for that command). The latest calculated *zero* and *gain* coefficients may be inspected with the **‘u’** command at any time for any channel.

Finally, this sub-command restores the original “A/D samples for averaging” count used by the module’s data acquisition process to the value that was in use before the **Multi-Point Calibration** function was originally started.

**Example:**

- Finish the **Multi-Point Calibration** function previously started (as indicated by the *previous examples* of **‘C’** sub-commands ‘00’ and ‘01’). Calculate new adjustment coefficients, and save them in the non-volatile memory of the module’s transducers. These new coefficients will then be used for all subsequently calculated EU data acquired by the module, until another calibration function is performed in the future.

  “**C 02**”
  “**w08**”
  “**w09**”

  Read responses (separately for each command executed above):

  **“A”**
  **“A”**
  **“A”**

  If an error (“N”) response is returned on the first command, either the correct number of calibration points (per ‘00’ sub-command) were not supplied with reasonable pressure data values (via the multiple ‘01’ sub-commands), or the collected data yielded new calculated coefficients with unreasonable values. In that case, the other two commands should **not** be used.

  If execution of the last two **‘w’** commands is skipped above, the new calibration data obtained will be stored only in volatile storage, and will be available for use only until the module is RESET or loses power.

### *Command 'C'— Sub-command Index 03: Abort Multi-Point Calibration*

This sub-command has no additional parameters.

| | |
|---|---|
| **Command** | "**C 03**"<br><br>'C' is the *command* letter.<br>'03' is the *sub-command index* (*ii*) for *Abort*.<br><br>**NOTE: all parameters are separated by a *space*.** |
| **Response** | "**A**"<br><br>'A' is the *acknowledge* letter |

**Description:** Aborts the **Multi-Point Calibration** function, if it is currently in progress. This sub-command also restores the original "A/D samples for averaging" count to the module that was in use before the calibration function was started.

It should be noted that executing the *Configure & Start* ('00') sub-command again, after the calibration function has started collecting data (per *Collect Data* ('01') sub-commands), but before the final data are calculated (per *Calculate & Apply* ('02') sub-command), will have the same affect as this Abort function.

**Example:**

- Abort the Multi-Point Calibration function previously started

  "**C 03**"

  Read response:

  "A"

## READ TRANSDUCER VOLTAGES (Command 'V')

**Purpose:** Returns for the specified channels, the most recently acquired *raw pressure* data, converted to volts directly from the averaged A/D counts. This simple engineering-unit conversion bypasses any usage of the transducer's factory-calculated coefficients or the final calibration process's *correction* coefficients (offset and gain). Each datum returned in the response will be in the specified high-precision data format. **This command is intended for advanced users** only and is not required for normal operation.

| | |
|---|---|
| **Command** | "**V*ppppf***"<br><br>'V' is the *command* letter<br>'*pppp*' is the *position* field<br>'*f*' is the *format* field |

**Response** " ***dddd.. [dddd]***"

' *dddd*' are the *data* fields, each with a leading space (except *f* =7 or 8).

**Description:** The 4-character hex *position* field *(pppp)* specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *datum* field (' *dddd*') that will be returned in the requested response. The first datum returned in the response will be for the highest channel number requested, and each (non-binary) datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

| ***f*** | **converts each internal response *datum* value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | single binary float | to | 7-10-digit signed decimal " [-xxx]x.xxxxxx" | 13 |
| 1 | single binary float | to | 8-digit hex integer " xxxxxxxx" | 9 |
| 2 | double binary float | to | 16-digit hex integer " xxxxxxxxxxxxxxxx" | 17 |
| 5 | single binary float | to | long integer (EU*1000) then to 8-digit hex integer | 9 |
| 7 | single binary float | to | single binary float (big endian: msb first) | 4 |
| 8 | single binary float | to | single binary float (little endian: lsb first) | 4 |

Example:

- Send TCP/IP command to a **Model 9116** module (via its connected socket) that returns ASCII decimal fixed-point voltage data for channels 1, 5, 9, and 13:

  "**V11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  " **4.999999  -4.989500  0.005390  2.500001**"

## CALCULATE AND SET GAINS (Command 'Z')

**Purpose:** Instructs a module to calculate new *gain* coefficients, with either *full-scale* pressure (or a *specified* pressure) applied to the specified channels. These new coefficients update part of the module's internal calibration coefficient database, used to convert any subsequent raw data (from any of the specified channels) into engineering units data. The new gain values are also returned in the response. This command is sometimes called a *Span or Span-only* calibration.

| | |
|---|---|
| **Command** | "Z***pppp*****[ *vv.vvvv*]**"<br><br>'Z' is the *command* letter<br>'*pppp*' is the *position* field<br>' *vv.vvvv*' is an [optional] *pressure* value, preceded by a *space* character. |
| **Response** | "**g.gggg .. g.gggg**"<br><br>'*g.gggg*' are the actual *gain* data values returned, each preceded by a *space*. |

**Description:** The *position* field may have 0 or 4 characters. If no *position* field is specified, *gain* coefficients for all module input channels will be calculated and returned. If a *position* field is specified, *gain* coefficients for only the channels whose bits are set (=1) will be calculated and returned. If the optional *pressure* value (*vv.vvvv*) is specified, the *position* field must be 4 characters, even when all channels are to be specified. *Gain* values are returned in the response in order of *highest* specified channel to *lowest* specified channel, with data formatted per an *implied* decimal format (*f*=0).

Normally this command requires that the *exact full scale* input pressure be applied to the affected channels. The optional *pressure* value [ *vv.vvvv*] allows the user to specify *any suitable upscale pressure* in the current engineering units. For best results, pressures in excess of 90% of full scale should be applied. A leading *space* character must precede the *pressure* value parameter.

The desired calibrating pressure must be applied to all of the specified channels and allowed to stabilize before this command is executed. Such a pressure is presumably generated by a separate model 903x calibrator module or suitable user-supplied substitute.

Notice that unlike the ***Calculate and Set Offsets*** **('h')** command, this command does not automatically move a **Model 9116** module's calibration valve to its Cal position. A command to do this must precede this command. The reader is referred to **Chapter 4, Section 4.3** for additional details concerning the performance of a Span Calibration.

Internal firmware limits calculated gains to values are software limited to values between 0.0 and 100.0. Any calculated value outside of this range will result in the gain coefficient being set to 1.00.

Note

**The calculated *gain* values from the latest 'Z' command will be lost when the module is powered off. To save these *gain* terms to each transducer's non-volatile memory, refer to the *Set Operating Options* ('w') command (index 09).**

Example:

- Send TCP/IP command to a **Model 9116** module (via its open socket) to calculate and set gain coefficients for channels 8 through 4. Instruct the module to use 14.8890 psi as the applied pressure instead of each transducer's full-scale value:

  "**Z00F8 14.8890**"

  Read response, containing the new gain values (also stored in the module's volatile main memory):

  "**1.000212 1.000269 1.000437 1.000145 .999670**"

  Actual gain values are returned in the above response as decimal ASCII strings, each preceded by a *space* character. From left-to-right: they are for channels 8, 7, 6, 5, and 4.

## READ TRANSDUCER A/D COUNTS (Command 'a')

**Purpose:** Returns the most recently acquired *raw pressure* data for the specified channels in averaged signed A/D counts (in the range -32768 to +32767). This simple data bypasses any usage of the transducer's factory-calculated coefficients or the final calibration process's adjustment coefficients (offset and gain). Each datum returned in the response will be in the specified high-precision data format, but representing A/D counts as a signed integer average. (The formula for converting A/D counts to volts is: *Volts = A/D Counts * 5/32768*) This command is intended for advanced users only and is not required for normal operation.

| | |
|---|---|
| **Command** | "***appppf***"<br><br>'a' is the *command* letter<br>'*pppp*' is the *position* field<br>'*f*' is the *format* field |
| **Response** | " ***dddd.. dddd***"<br><br>' *dddd*' are the *data* fields, each with leading space (except *f* = 7 or 8). |

**Description:** The 4-character hex *position* field (*pppp)* specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right). Only channels 12-1 are allowed for Models 9021 and 9022.

The 1-character *format* field (*f)* specifies the format of each *data* field (*dddd*) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number requested. Each datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

| ***f*** | **converts each internal response *datum* value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | single binary float | to | 7-10-digit signed decimal " [-xxx]x.xxxxxx" | 13 |
| 1 | single binary float | to | 8-digit hex integer " xxxxxxxx" | 9 |
| 2 | double binary float | to | 16-digit hex integer " xxxxxxxxxxxxxxxx" | 17 |
| 5 | single binary float | to | long integer (EU*1000) then to 8-digit hex integer | 9 |
| 7 | single binary float | to | single binary float (big endian: msb first) | 4 |
| 8 | single binary float | to | single binary float (little endian: lsb first) | 4 |

**Example:**

- Send TCP/IP command to **Model 9116** module (via its connected socket) that returns decimal raw "pressure" A/D counts data for channels 1, 5, 9, and 13:

  "**a11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  " **32767.000000  -32700.000000 10.000000 16385.000000**"

  Please note that channel 13 is saturated at +full scale and channel 9 is almost saturated at -full scale.  Channel 5 reads near zero and channel 1 is about ½ +full-scale.

## READ HIGH-SPEED DATA (Command 'b')

**Purpose:** Returns the most recent scanned/averaged data from *all channels* of the module as fast as possible. Data is returned directly in its internal (IEEE single-precision float) binary form (as per *implied* format 7). It is used as a *faster alternative* to the *Read High-Precision Data* ('r') command, since 'b' does not have to parse the position or format parameters, nor does it have transform or encode the internal data into any other format when the response is generated.

| | |
|---|---|
| **Command** | "**b**"<br><br>'b' is the *command* letter |
| **Response** | "***aaaabbbbcccc..rrrr***"<br><br>each 4-byte datum (e.g, '*aaaa*') is a non-human readable 32-bit (4-byte) big-endian value (format 7) representing an IEEE single-precision internal float value. |

**Description:** Returns data for all of the module's channels, in order highest channel number to lowest channel number. Thus for a **Model 9116**, channel #16 will always be the first 4-byte (32-bit binary, big-endian, IEEE floating-point) value ('*aaaa*') sent in the response. It is followed by similar values for lower numbered channels.

Unless the EU conversion scalar is altered, the returned data will be in units of psi.

**Example:**

- Send command to a module (via its "socket" connection) to return data as fast possible:

  "**b**"

  Data from the most recent scan of all the module's channels are returned in pure binary form, 4-bytes per channel (big endian):

  **aaaabbbbcccc .. rrrr**

  Note that this response is not shown within quotes " " since it is not a valid ASCII character string

## DEFINE/CONTROL AUTONOMOUS HOST STREAMS (Command 'c')

**Purpose:** Defines and controls the autonomous delivery of any of up to three concurrent high-speed *autonomous data streams* to the host computer. Such *data streams* may be delivered "continuously" without bound (i.e., until a command explicitly stops them), or be delivered in a "limited" amount (until a pre-specified fixed number of data packets have been sent). Each packet delivered may be synchronized by a user-supplied "hardware trigger" or each packet may be delivered periodically as synchronized by an internal software clock. These concurrent host streams are an alternate method of acquiring/delivering data rather than using the ***Read High-Precision Data*** (**'r'**) command, the ***Read High-Speed Data*** (**'b'**) command or the many other special purpose read commands ('**V**,' '**a**,' '**t**,' '**m**,' and '**n**,') for reading alternate data values.

Host data streams, once activated in a module, deliver a sequence of TCP/IP or UDP/IP data packets *autonomously* to the host (i.e., without the host sending any particular command to the module to request each packet).

**WARNING: If these data streams are defined to occur at high rates, then each data packet received by the host must be processed and disposed of in a timely manner. NetScanner™ System modules are capable of generating autonomous data faster than some "slow" hosts (or incapable software) can absorb.**

| | |
|---|---|
| **Command** | "**c *ii*[ *dddd*] ...** "<br><br>'c' is the *command* letter<br>' *ii*' is a *space* + a sub-command index (augment code)<br>' *dddd*' are one or more optional *datum* fields, each preceded by a *space* character which are parameters that differ per augment code *ii*.<br><br>**NOTE: all parameters are separated by a *space*.** |
| **Response** | Depends upon particular sub-command (' *ii*') sent. See below. |
| **Autonomous Packet** | Depends upon the particular sub-command (' *ii*') sent. See below. |

**Description:** The firmware of any module, once fully initialized, continuously scans and converts data for all pressure channels at the highest possible speed. The result of such scanning is a continuously updated *EU data buffer,* available to three concurrent host data delivery tasks, or available to other standard data acquisition commands in the module. Each host delivery task can grab engineering-unit data values from the *EU data buffer* and deliver them to the host in its own programmable data stream (a sequence of TCP/IP or UDP/IP packets that autonomously arrive in the host, as long as the host has enough TCP/IP buffering space to hold them).

Special augments of this command, called sub-commands (distinguished by the first parameter *ii*) can configure each data stream with the particular channels whose data are delivered, the datum format, the delivery rate, and other characteristics. It can also start, stop, or undefine a single stream or all defined streams.

The maximum rate of any one stream's delivery is practically limited to the maximum possible scan and data conversion rate of all the module's channels. Normally, these programmable host streams deliver host data at rates equal to or slower than this natural cycle. For a typical application, the first stream delivers a few channels at a high rate as defined by a hardware trigger. The second stream delivers other channels at a medium rate (some multiple of the trigger), and the third stream can deliver still other channels at a slow rate (a larger multiple of the trigger). In another application, the three streams might all be programmed to deliver all the same channels, but the first stream might deliver pressure data (EU only) at high speed. The second stream might deliver pressure counts or volts at a slower rate, and the third stream might deliver temperature in all forms (EU, counts, volts) at a very slow rate.

**Note**

**Avoid confusing this *Configure/Control Autonomous Host Streams* command 'c' (lower case c) with the *Configure/Control Multi-Point Calibration* command 'C' (upper case C). Like 'C', but unlike most other module commands, all sub-commands of this command require a *space* between the *command id* ('c') and the first parameter (*ii*).**

## Command 'c'— Sub-command Index 00: *Configure A Host Delivery Stream*

This sub-command is used to configure the *principal* parameters of each of the three possible concurrent host delivery streams, one at a time. Following this configuration phase, the stream (1, 2, or 3) or all streams may be started and stopped with other sub-commands. The sub-command's format is:

| | |
|---|---|
| **Command** | "**c 00** ***st [[[[p]p]p]p sync per f num***"<br><br>'c' is the *command* letter<br>'00' is the *sub-command index* (*ii*) for configuration<br>'*st*' is the *stream id* digit (1, 2, or 3)<br>'[[[[*p]p]p]p*' is a 1-4 hex digit *position* field (channel selection bit map) capable of selecting 1-16 internal channels<br>'*sync*' is *sync type* character (0= hardware trigger or 1= clock)<br>'*per*' is the *period* (if *sync*=0: # of trigger periods or if *sync*=1: delay timer period in msec).<br>'*f*' is the *format* of each acquired datum in stream<br>'num' is the *number of packets delivered* in the stream (0=unlimited/continuous).<br><br>**NOTE: all parameters are separated by a space character**. |
| **Response** | "**A**"<br>'A' is the *acknowledge* letter |
| **Autonomous Packet** | none generated |

**Description:** Configures a particular stream ('***st***') to deliver data packets autonomously to the host, with each packet containing selected acquired data for the channels specified. The channels are specified by a standard 16-bit *position* field bit map (encoded as a 1-4 hex digit *position* field ([[[[***p]p]p]p***). A separate sub-command (*ii*=05) may be used to select which *acquired data* are included in each stream. By default, only pressure (EU) data are selected (if *ii*=05 sub-command is never executed for the stream).

The individual data packets of the stream may be synchronized with either an external user-supplied hardware trigger or a periodic clock interrupt generated inside each module. This choice is made with the *sync type* '***sync***' parameter (a single digit) where: 0 = synchronize with hardware trigger; 1= synchronize with periodic software clock.

When the **hardware trigger** is used to synchronize **data output** ( *sync* = 0), it is assumed that the user would prefer to also synchronize internal data acquisition cycle. For this reason, when a stream utilizing hardware trigger is started, the module firmware switches out of the free-running continuous data acquisition mode described earlier. Instead, the module waits in an idle mode until a hardware trigger is received to initiate a host stream output. Only on the receipt of that hardware trigger will the module scan and EU convert all attached

channels. Following completion of the acquisition and EU conversion cycle, the module will also deliver the requested data channels to the host. In this manner, users are provided with highly synchronized data acquisition *and* delivery from one or more modules. If a module waits in the idle mode for an extended period of time without receiving a data request, it will periodically initiate its own internal data acquisition cycles so as to update internal thermal coefficients.

When all hardware triggered streams are complete or aborted, an individual module will return to the default mode of continuous scanning and EU conversion.

When the **internal software timer** is used to control host stream output rates (*sync*=1), note that internal clock frequency variances will result in slightly different timing between modules. Although these differences in timing are slight, they may result in noticeable differences in output timing between modules over a long period of time. If highly synchronized data output is required from multiple modules, the hardware trigger mode should be used.

The period '***per***' parameter is a positive decimal integer count (from 0 to 2147483647, specified with 1 to 10 numeric digits as needed), and its meaning depends on the *sync type* '***sync***' parameter described above.

| ***'sync'*** | **meaning of 'per'** |
|---|---|
| 0 | number of hardware trigger periods to wait before sending each packet |
| 1 | delay period (in milliseconds) to wait before sending each packet<br>**NOTE:** minimum is 2 milliseconds and the granularity is 2 milliseconds with values rounded down to the nearest 2 milliseconds. |

The '***f***' parameter identifies the *format* of each selected acquired datum in each stream packet, and is a single numeric digit. Valid format codes are listed in the following table:

| ***f*** | **converts each internal *selected acquired datum* value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | single binary float | to | 7-10-digit signed decimal " [-xxx]x.xxxxxx" | 13 |
| 1 | single binary float | to | 8-digit hex integer " xxxxxxxx" | 9 |
| 2 | double binary float | to | 16-digit hex integer " xxxxxxxxxxxxxxxx" | 17 |
| 5 | single binary float | to | long integer (EU*1000) then to 8-digit hex integer | 9 |
| 7 | single binary float | to | single binary float (big endian: msb first) | 4 |
| 8 | single binary float | to | single binary float (little endian: lsb first) | 4 |

Unless the EU conversion scalar is altered, the returned pressure data will be in units of psi.

(See command 'v', array 11, coefficient 01 for other units.

Note

**With the exception of binary formats 7 and 8, all other formats include a leading *space* in each datum delivered in each stream packet.**

The *number of stream packets* (*'num'*) parameter is a positive integer count (from 0 to 2147483647, specified with 1 to 10 numeric digits as needed). It sets a finite limit on the number of packets delivered in the host data stream. The value 0 for this parameter requests "continuous" output packets for the defined host stream (unbounded).

Note

**While the 'c 00' command will allow hardware and software trigger scan lists to operate concurrently, this is not a recommended mode of operation. Running hardware and software trigger scan lists concurrently diminishes the degree of determinism for the hardware scan lists. The hardware trigger lists will determine the frequency of pressure readings and the update of internal pressure, current value table. The software trigger lists will return data from this table at the requested software trigger rate, however the table will only be updated at the rate of the fastest hardware trigger scan lists.**

**Example:**

- Configure three (3) separate autonomous host delivery streams, and divide the module’s channels between them. Channels (1-4) must be delivered to host as fast as possible, channels 5-8 may be delivered at half that rate, while the remaining channels 9-16 are delivered at half the previous rate. All streams are generated continuously and synchronized with the internal clock at 100 msec., 200 msec., and 400 msec. periods, respectively. Data are requested in single precision binary IEEE float format *f*=7).

  “**c 00 1 000F 1 100 7 0**”
  “**c 00 2 00F0 1 200 7 0**"
  “**c 00 3 FF00 1 400 7 0**"

  Read response:

  **“A”**
  **“A”**
  **“A”**

  To similarly acquire data at “relative” rates (1, 2, and 4) using a periodic *hardware* trigger (assumed to also cycle at 10 Hz rate), enter the commands:

  “**c 00 1 000F 0 1 7 0**”
  “**c 00 2 00F0 0 2 7 0**”
  “**c 00 3 FF00 0 4 7 0**”

  Read responses:

  “**A**”
  “**A**”
  “**A**”

**Note**

| |
|---|
| **The type of data delivered for each specified channel (when the streams are started) is EU pressure unless sub-command “05” is also executed to select other types of data in each stream.** |

### Command 'c'— Sub-command Index 01: *Start Stream(s)*

This sub-command is used to start the delivery of any previously configured host stream in a module. If the stream started is of "continuous" duration, then it will be necessary to use the Stop Stream sub-command later. Otherwise, the stream will end automatically if a finite number of packets has been specified for it. This sub-command may also be used to resume a previously stopped host stream that has not transmitted all requested data packets. The sub-command's format is:

| | |
|---|---|
| **Command** | "**c 01 *st***"<br><br>'c' is the *command* letter<br>'01' is the sub-command index ('*ii*') for ***Start Stream(s)***<br>'*st*' is the *stream id* digit (1, 2, or 3, or 0=*all streams*)<br><br>**NOTE: all parameters are separated by a space character**. |
| **Response** | "**A**"<br>'A' is the *acknowledge* letter |
| **Autonomous Packet** | "*tssss[dddd] .. [dddd]*"<br><br>'*t*' is a 1-byte binary (8-bit) value identifying the stream number (1-3).<br>'*ssss*' is a 4-byte binary integer (32-bit, big-endian) packet sequence. number. Optional binary status may follow the sequence number. (See "**05**" sub-command.)<br>'*dddd*' are the *acquired datum* values in the selected format plus a leading *space* (except *f*=7 or 8). |

**Description:** This sub-command starts a particular specified host stream (*st*=1-3), or starts all configured host streams with a single command (*st*=0). Each autonomous host stream packet begins with a 5-byte fixed-format (binary) data header (*tssss*). The first byte (*t*) identifies the host stream, while a 32-bit unsigned binary sequence number (*ssss*) completes the header. This sequence number will start at one (1) for the first packet returned by a stream and increment for each other returned packet of that stream. In the case of a "continuous" data stream, the sequence number may overflow the maximum permissible 32-bit integer value. If this occurs, the sequence number value will wrap around to zero (0) following the largest 32-bit value (4294967295) and then continue to increment by one for each returned packet. The sequence number field is intended to provide a mechanism for host software to ensure that host data stream packets are processed or stored in the order in which they were obtained by the module. Each of the three possible host streams will report their own unique sequence number. Note that if a previously stopped data stream is restarted, the returned sequence numbers will resume with the next number at the point of the stream's termination. The sequence numbers will not restart at one (1) if a scan list is temporarily stopped and then restarted without reconfiguring the stream. A "limited" stream will terminate once this sequence number equals the requested number of packets for the stream. If a "limited" stream is restarted after expiring, it will restart at sequence number 1.

For periodic hardware-triggered streams, that are never suspended and resumed after being initially enabled, the sequence number may also serve as a "relative" time stamp if the *period* (in milliseconds) of the hardware trigger is known.

If a special sub-command (*ii*=05) is used to select the content of a stream, other binary *status* data may immediately follow the binary stream header and *precede* the default Pressure EU Data (if selected). Other *special* acquired data groups (per selected channel) may follow or replace the Pressure EU Data. Each datum group in each packet will be ordered from highest channel number requested to lowest channel number requested. Each datum (*dddd*) will be output per the format code specified when the stream was configured (by sub-command "**00**" or combination of "**00**" and "**05**").

**Example:**

- Start all the streams configured in the previous example:

  "**c 01 0**"

  Read response:

  **"A"**

  Soon after the response is received, the requested data stream packets will begin arriving in the host at a quantity, content, and rate determined by each stream's own particular current configuration (per both the "**00**" and "**05**" sub-commands).

## Command 'c'— Sub-command Index 02: *Stop Stream(s)*

This sub-command is used to stop (or temporarily suspend) the delivery of any previously started host stream in a module, one at a time or all together, whether the stream was "continuous" or "limited." The sub-command's format is:

| | |
|---|---|
| **Command** | "**c 02 *st***"<br><br>'c' is the *command* letter<br>'02' is the sub-command index ('*ii*') for ***Stop Stream***<br>'*st*' is the stream *id* digit (single stream 1, 2, or 3, or 0=*all streams*)<br><br>**NOTE: all parameters are separated by a *space*.** |
| **Response** | "**A**"<br>'A' is the *acknowledge* letter |
| **Autonomous Packet** | command stops generation of autonomous packets from the requested stream(s). |

**Description:** This sub-command stops the current "run" of a particular specified host stream (*st*=1-3), or stops the current "run" of "all configured" host streams with a single command (*st*=0).

Any stopped stream may be resumed (i.e., restarted) with the *Start Stream* sub-command as long as that stream remains defined in the module and any limited sequence count has not yet expired. The *Clear Stream* sub-command may be used to undefine a stream. Any continuous stream or unexpired limited stream that is restarted continues generating new sequence numbers (i.e., at the count where it left off when stopped). However, the stream must be reconfigured with the *Configure a Host Delivery Stream* sub-command (00) before it restarts with sequence count =1. Any expired limited stream must be reconfigured to restart at all.

**Example:**

- Stop all the streams configured in the previous example:

  "**c 02 0**"

  Read response:

  **"A"**

## Command 'c'— Sub-command Index 03: *Clear Stream(s)*

This sub-command is used to "undefine" any previously configured host stream in a module, one at a time, or all together. The sub-command's format is:

| | |
|---|---|
| **Command** | "**c 03 *st***"<br><br>'c' is the *command* letter<br>'03' is the sub-command index ('*ii*') for configuration<br>'*st*' is the stream identifier character (1, 2, or 3 or 0=*all streams*)<br><br>**NOTE: all parameters are separated by a *space* character**. |
| **Response** | "**A**"<br>'A' is the *acknowledge* letter |
| **Autonomous Packet** | none generated |

**Description:** This sub-command *clears* (un-defines) the particular specified host stream (*st*=1-3), or un-defines "all configured" host streams with a single command (*st*=0). Once cleared, a stream must be reconfigured before it can be started.

**Example:**

- Stop all the streams configured previously. Then clear (un-define) only stream 3. Finally, resume the remaining defined streams 1 and 2:

  "**c 02 0**"
  "**c 03 3**"
  "**c 01 0**"

  Read response:

  **"A"**
  **"A"**
  **"A"**

## Command 'c' — Sub-command Index 04: *Return Stream Information*

This sub-command returns current stream configuration information in its response. Its format is:

| | |
|---|---|
| **Command** | "**c 04** ***st***"<br><br>'c' is the *command* letter<br>'04' is the sub-command index ('*ii*') for configuration<br>'*st*' is the stream identifier character (1, 2, or 3 **only**)<br><br>**NOTE: all parameters are separated by a *space* character**. |
| **Response** | "***st [[[[p]p]p]p sync per f num pro remport ipaddr bbbb*** "<br><br>'st' is the *stream identifier* digit (1,2, or 3)<br>' *pppp*' is a hex *position* field (channel selection bit map)<br>'*sync*' is *sync type character* (0 or 1)<br>'*per*' is the *period* (# trigger periods or delay timer period)<br>'*f*' is the *format* of the data delivered in stream<br>'*num*' is the *number of packets delivered* in the stream<br>'*pro'* identifies the protocol used for stream delivery (1=UDP/IP, 0=TCP/IP. This protocol identifier pertains to stream delivery **only**.<br>*'remport'* identifies the remote port number to which each stream delivery is directed in the host. A value of -1 indicates that stream delivery is directed to the same port number the host is using to send commands to the module.<br>*'ipaddr'* identifies the IP address of the host to which the stream delivery is directed.<br>*'bbbb' another position field (data options bit map) as specified by the "**05**" sub-command.*<br><br>**NOTE: All datum fields separated by a *space* character.** |
| **Autonomous Packet** | none generated |

**Description:** This sub-command returns current configuration information for a particular stream. Returned values are defined the same as the sub-command parameters of separate commands *Configure a Host Delivery Stream* ("**00**," *Select Protocol*, "**06**," and *Select Data in a Stream,* "**05**."). Note that the '*num*' field represents the number of packets returned so far (= last sequence number returned, or =0 if stream not yet started.

**Example:**

- Return configuration information for stream l

  **"c 04 1"**

  Read response:

  **"1 FFFF 0 20 7 32000 1 7002 200.200.200.1"**

  The above example shows all 16 (sixteen) channels. Data is acquired using hardware trigger with one (1) data packet acquired for every trigger events. Data is returned in format 7. (In the above example, 32000 packets have been returned so far.) Data is sent using UDP protocol to port 7002 at IP address 200.200.200.1. Pressure EU data **only** is returned for the requested channels.

## Command 'c' — Sub-command Index 05: *Select Data in a Stream*

This sub-command sets options that cause a specified stream to deliver specific kinds of information to host. By default, only Pressure EU data are delivered for the channels already specified by the "**00**" command.

| | |
|---|---|
| **Command** | "**c 05 *st bbbb***"<br><br>'c' is the *command* letter<br>'05' is the *sub-command index* ('*ii*') for ***Select Data***.<br>'*st*' is the *stream id* digit (1, 2, or 3, (0 not allowed)<br>' *bbbb*' is the hex option field (bit map) to select which options will be returned in the data stream (see table)<br><br>**NOTE: all parameters are separated by a *space* character**. |
| **Response** | "**A**"<br>'A' is the *acknowledge* letter |

**Description:** If this sub-command is never executed for a particular stream, then **Pressure EU Data** are delivered (by default) in that stream following the fixed format binary header ( *tssss* as described by the "**01**" sub-command). However, this sub-command may also *delete* these default pressure readings from a stream (by **not** specifying them) as well as *add other* selected acquired data to a stream (by specifying them).

The *bit map values* (shown in the following table) may be added together to specify *all* the actual data groups that will be delivered in each packet of the specified stream. The first two table entries, if their "bits" are specified, will cause two-byte binary (16-bit, big endian) *status* values to be delivered in the stream packet (immediately following the binary stream header). The third table entry, if specified, will cause the **Pressure EU Data** to be delivered (next), per the specified format (*f*), and for just the channels specified in the configured stream. The remaining table entries will cause other *special* data groups (i.e., raw pressures and EU temperature values, also in A/D counts or voltage forms) to also be delivered in each stream packet. Each of these *special* data groups is also output, if its "bit" is specified, in the order of its table entry (within the packet). Each group will also have a datum per the specified channels, and be in the specified format (per *f*).

**Note**

| |
|---|
| **Selecting too many other data groups will compromise module performance.** |

| ***bbbb (hex)*** | **data selected for inclusion in each stream packet** |
|---|---|
| 0001 ** | Enable **Valve Position Status** (reserved for future use) |
| 0002 | Enable **DH Temperature Status** (see bit map below) |
| 0010 | Enable **Pressure EU Data** (default if “**05**” never executed after “**00**”) |
| 0020 | Enable **Pressure A/D Counts** |
| 0040 | Enable **Pressure Voltages** |
| 0080 | Enable **DH Temperature EU Data (degrees C)** |
| 0100 | Enable **DH Temperature A/D Counts** |
| 0200 | Enable **DH Temperature Voltages** |

Any **DH Temperature Status** datum is delivered as a two-byte binary bit map (16-bit, big endian) with each bit representing the status of DH #16 through DH #1 respectively. A bit value of 0 (zero) indicates the DH is operating within its specified limits. A value of 1 (one) indicates the DH is outside its specified limits.

| Bit # | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chan # | **16** | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | **1** |
| Binary | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Hex | 8 | | | | 0 | | | | 0 | | | | 1 | | | |

The above example indicates that Channels 1 and 16 are operating outside the specified temperature limits.

Note

** **This status field (0001) cannot be specified for Model 9116. However it is shown should the capability be added to future firmware versions. Currently, only Models 9816 and 903x can return Valve Position status in their streams.**

**Example:**

- Configure stream l to return temperature status field, and all Pressure EU data

  **"c 05 1 0012"**

  Read response:

  **"A"**

  If or when stream 1 is subsequently enabled, data groups in that stream with the *lowest-bit-numbers (table positions)* selected are delivered first. In this example (*bbbb* = 0012), the **DH Temperature Status** datum would be first, and then all the specified **Pressure EU** data would follow (highest specified channel to lowest specified channel). The standard 5-byte binary prefix (*tssss*) that begins all stream packets would precede this status and data group.(See the Autonomous Packet box in **Start Stream** sub-command (index 01.)

## Command 'c' — Sub-command Index 06: *Select Protocol For Stream Delivery*

| | |
|---|---|
| **Command** | "**c 06 *st* *pro* [*remport* [*ipaddr*]]**"<br><br>'c' is the *command* letter.<br>' 06' is the *sub-command index* (*ii*) for ***Select Protocol***.<br>' *st*' is the *stream* id digit (0=the ONLY acceptable entry).<br>' *pro*' is the *protocol* id digit (1=UDP/IP, 0=TCP/IP)<br>' *remport*' is an optional *remote port number* to which each UDP stream is directed in the host (port 9000 is the default if unspecified). It is ignored if *pro*=0.<br>' *ipaddr*' is an optional host *IP address* to which each UDP stream is directed (default is the host IP address per current TCP connection that sent this command). It is ignored if *pro*=0.<br><br>**NOTE: all parameters separated by a *space*.** |
| **Response** | "**A**"<br>'A' is the *acknowledge* letter |

Description: This command sets the protocol by which every configured autonomous stream is delivered to the host. **It must be executed after streams are configured, but before they are enabled.**

By default, streams are delivered via the same TCP/IP protocol used to receive commands from host (i.e., via the existing TCP/IP connection used to send this command). However, for special circumstances, all autonomous streams may be delivered to the host via the UDP/IP protocol instead. This command is required only when UDP/IP is to be used. It also can restore the default protocol (to TCP/IP) once it has been changed. The TCP/IP version of the command ignores the optional (*pro* and *ipaddr*) parameters, which have meaning only to the UDP/IP protocol.

Though the command has a *stream* parameter, it is currently limited to changing the protocol of *all defined streams* at the same time (i.e., parameter *st* **must** be = 0, meaning *all configured* streams).

The optional *remport* parameter may be any value in the range 1024 to 65535. However, *remport* = 7001 should be avoided, since NetScanner modules emit *UDP Query* responses to that port, and most host programs should have a UDP socket already bound to that port for receiving these special responses. The choice of *remport* parameter will affect the way host software must handle multiple modules sending streams. If every module uses the same port, then a single host socket can be bound to that port to receive all responses from all modules. The remote IP address, given to that socket, at time of receipt of the stream's datagram, will identify the particular module who sent the datagram. Alternately, every module may be given a unique *remport* number, requiring that a host program bind a unique UDP socket to each of these unique *remport* numbers. Then, when a particular socket receives a UDP datagram to its unique port, the module sending it is automatically identified.

The optional *ipaddr* parameter is normally unspecified, causing it to default to use the IP address of the current TCP/IP connection. That way the host need not have to be aware of its own IP address. This parameter is provided in case a special host has multiple network interfaces and wants to use more than one. When used, *ipaddr* requires four dotted numeric fields (*d.d.d.d*). Each *d* is a 1-3 digit decimal number in the range 0-255. The *ipaddr* = 255.255.255.255 is best avoided, unless the UDP datagrams of streams are to be broadcast to all network nodes.

**Example:**

- Configure all streams to be delivered via UDP/IP protocol. Host expects the UDP datagrams to arrive via port 7500. The IP Address of the current TCP/IP connection is also used to send each UDP datagram.

  **"c 06 0 1 7500"**

  Read response:

  **"A"**

- Configure all streams to be delivered via the default TCP/IP protocol.

  **"c 06 0 0"**

  Read response:

  **"A"**

## CALCULATE AND SET OFFSETS (Command 'h')

**Purpose:** Instructs a module to calculate new offset coefficients with zero differential pressure (or a *specified* "generated" pressure) applied to the specified channels. These new coefficients update part of the module's internal calibration coefficient database, used to convert any subsequent raw data into engineering units data. The new offset values are also returned in the response. This command is sometimes called a Re-zero or zero-only calibration.

| | |
|---|---|
| **Command** | "***hpppp [vv.vvvv]***"<br><br>'h' is the *command* letter<br>'*pppp*' is the *position* field<br>**'*vv.vvvv*'** is an [optional] *applied pressure value* preceded by a *space* character |
| **Response** | "***g.gggg .. [g.gggg]...***"<br><br>'*g.gggg*' are the actual *offset* data values returned, each preceded by a *space.* |

**Description:** The *position* field may have 0 or 4 characters. If no *position* field is specified, *offset* coefficients for all of a module's input channels will be calculated and returned. If a *position* field is specified, *offset* coefficients for only the channels whose bits are set (=1) will be calculated and returned. If the optional pressure value [ *vv.vvvv*] is specified, the position field must be 4 characters, even when all channels are to be specified. If the *optional pressure value* ['***vv.vvv***'] is not provided, an applied pressure of 0.0 psi(a) will be assumed when calculating coefficients. Offset values are returned in the response in order of *highest specified channel* to *lowest specified channel*, with data formatted per an *implied* decimal format (*f*=0).

Before acquiring data with this command, any addressed **Model 9116** module will *normally* attempt to place the calibration valve in the CAL position, so that a zero differential pressure can be applied to all channels via the module's CAL and CAL Ref input port. Simply leaving these ports unattached will allow the transducers to read the appropriate zero differential pressure if ambient air pressure is stable. After data are acquired, the calibration valve will be placed in the RUN position. To disable the automatic shifting of the calibration valve, refer to the ***Set Operating Options*** (**'w'**) command (index 0B). The reader is also referred to **Section 4.2** of **Chapter 4** for additional details concerning the performance of a Re-zero Calibration.

**Note**

**The calculated offset values from the latest 'h' command will be lost when the module is powered off. To save these offset terms to each transducer's non-volatile memory refer to the *Set Operating Options* ('w') command (index 08).**

**Example:**

- Send TCP/IP command to a **Model 9116** module (via its open socket) to calculate and set new offset coefficients for channels 16 through 13.

  "**hF000**"

  Read response, containing all new offset values (also stored in the module's volatile main memory):

  "**0.0010 0.0020 0.0015 0.0025**"

  Actual offset values are returned in the above response as decimal fixed-point ASCII strings, each preceded by a *space* character. From left-to-right: they are for channels 16, 15, 14, and 13.

## READ TEMPERATURE COUNTS (Command 'm')

**Purpose:** Returns the most recently acquired *raw temperature* data for the specified channels in averaged A/D counts (in the range -32768 to +32767). This command is similar to command '**a**,' except that the raw data reflects a channel's *temperature* signal instead of its *pressure* signal. Each datum returned in the response will be in the specified high-precision data format, but representing A/D counts as a signed integer average. This **command is intended for advanced users only and is not required for normal operation**.

| | |
|---|---|
| **Command** | "**m*ppppf***"<br><br>'m' is the *command* letter<br>'*pppp*' is the *position* field<br>'*f*' is the *format* field |
| **Response** | " ***dddd.. dddd***"<br><br>' *dddd*' are the *datum* fields, each with a leading ***space*** (except *f*= 7 or 8). |

**Description:** The 4-character hex *position* field (*pppp*) specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field *(f)* specifies the format of each *data* field (*dddd*) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number supplied, and each (non-binary) datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

| ***f*** | **converts each internal response *datum* value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | single binary float | to | 7-10-digit signed decimal " [-xxx]x.xxxxxx" | 13 |
| 1 | single binary float | to | 8-digit hex integer " xxxxxxxx" | 9 |
| 2 | double binary float | to | 16-digit hex integer " xxxxxxxxxxxxxxxx" | 17 |
| 5 | single binary float | to | long integer (EU*1000) then to 8-digit hex integer | 9 |
| 7 | single binary float | to | single binary float (big endian: msb first) | 4 |
| 8 | single binary float | to | single binary float (little endian: lsb first) | 4 |

**Example:**

- Send TCP/IP command to **Model 9116** module (via its connected socket) that returns decimal raw "temperature" A/D counts data for channels 1, 5, 9, and 13:

  "**m11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  "**20692.000000 19783.000000 19204.000000 20432.000000**"

## READ TEMPERATURE VOLTAGES (Command 'n')

**Purpose:** Returns the most recently acquired *raw temperature* data for the specified channels converted to engineering-unit Volts directly from the averaged A/D counts. It is similar to command **'V,'** except that the raw data reflects a channel's *temperature* signal instead of its *pressur*e signals. Each datum returned in the response will be in the specified high-precision data format. **This command is intended for advanced users only and is not required for normal operation.**

| | |
|---|---|
| **Command** | "**n***ppppf*"<br><br>'*n*' is the *command* letter<br>'*pppp*' is the *position* field<br>'*f*' is the *format* field |
| **Response** | " ***dddd.. dddd***"<br><br>' *dddd*' are the *datum* fields, each with a leading ***space*** (except *f*= 7 or 8). |

**Description:** The 4-character hex *position* field (pppp) specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *datum* field (*dddd*) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number supplied, and each (non-binary) datum will be preceded by a ***space*** character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

| ***f*** | **converts each internal response *datum* value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | single binary float | to | 7-10-digit signed decimal " [-xxx]x.xxxxxx" | 13 |
| 1 | single binary float | to | 8-digit hex integer " xxxxxxxx" | 9 |
| 2 | double binary float | to | 16-digit hex integer " xxxxxxxxxxxxxxxx" | 17 |
| 5 | single binary float | to | long integer (EU*1000) then to 8-digit hex integer | 9 |
| 7 | single binary float | to | single binary float (big endian: msb first) | 4 |
| 8 | single binary float | to | single binary float (little endian: lsb first) | 4 |

**Example:**

- Send TCP/IP command to **Model 9116** module (via its connected socket) that returns decimal voltage data (of the raw *temperature* signal) for channels 1, 5, 9, and 13:

  “**n11110**”

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  “ **0.53013 0.541698 0.503633 0.000000**”

  In this example channels 13, 9, and 5 return normal temperature voltage signals in the range of 0.5 to 0.6 volts. Note that channel 1 returns a value of 0.0 volts, indicating a possible error in its temperature signal.

## READ MODULE STATUS (Command 'q')

**Purpose:** Returns requested module status information.

| | |
|---|---|
| **Command** | "**q*ii***"<br><br>'*q*' is the *command* letter<br>'*ii*' is the *status index* field |
| **Response** | "***hhhh***"<br>'*hhhh'* is a 4-digit hex datum (or other (**) decimal datum |

**Description:** The 2-digit hex *index* field (*ii*) chooses a particular status field to be returned. Returned value is described in the following table for each index (a third column shows *any* **'w'** command index for **setting** same option.

| ii | returned value<br>4-digit hex or other decimal (**) | 'w' set index |
|---|---|---|
| 00 | **Module's Model Number**, as decimal (**) integer value (e.g, 9116). | |
| 01 | **Firmware Version**, as hex value<br>(expressed internally as integer *version* * 100).<br>(e.g. hex '0100' = 256 decimal, means Version 2.56) | |
| 02 | **Power-up Status**, as 16-bit hex bit map, bits having the following meaning: | |
| | Bit 0 (LSB): A/D Failure Error. | |
| | Bit 1: Transducer Re-zero Adjustment (offset) Term Range Error (out-of-range values set to 0.0 internally). | |
| | Bit 2: Transducer Span Adjustment (gain) Term Range Error (out-of-range values set to 1.0 internally). | |
| | Bit 3: Temperature Correction Coefficients Not Present or Out-of-Range (if transducer has one or more bad coefficients, all set to 0.0). | |
| | Bit 4: reserved (for transducer checksum) | |
| | Bit 5: FLASH Initialized Data Section Checksum Error (if error, all data variables set to factory defaults and stored in FLASH). | |
| | Bit 6: SRAM Error. | |
| 03 | reserved | |
| 04 | reserved | |
| 05 | **Number of A/D Samples To Average**, as hex value (e.g., 000A=10 decimal). | 10 |

| | | |
|---|---|---|
| 06 | **IP Address Resolution Method**, as hex state: (default = 0000)<br>0000 = **Use Static IP Address** stored in module's non-volatile memory<br>0001 = **Get Dynamic IP Address** from external RARP/BOOTP server | 13 |
| 07 | **Host Response/Stream Back-Off Delay**, as hex *value* (or FFFF). FFFF means use low-order byte of module's Ethernet Address as *value* instead. In either case, *back-off delay* in *microseconds* is calculated from *decimal* equivalent of hex *value*:<br>delay = *decvalue* * 20 | 14 |
| 08 | **Host Response/Stream Total Size Prefix** (with 2-byte big-endian binary value), added to all command responses and streams to indicate their true length in bytes:<br>0000 = None (default)<br>0001 = Yes | 16 |
| 09 | **TCP Connect Port**, as hex value (e.g. 2328 = 9000 *decimal*, default). | 17 |
| 0A | **Auto UDP Broadcast@Reset**, as hex state:<br>0000 = No (default)<br>0001 = Yes | 18 |
| 0C | **Temperature Status of Each Scanner Transducer**, as 16-bit hex bit map, each bit representing the current status of a transducer/channel (16-1)). Bit values are:<br>0= transducer operating within the specified operational limits.<br>1= transducer operating outside the specified limits.<br>(see end-of-table NOTE +) | |
| 0D | **Minimum Temperature Alarm Set Point** (in degrees C), as decimal (**) format 0 representation of internal IEEE float, with leading *space*). | 19 |
| 0E | **Maximum Temperature Alarm Set Point** (in degrees C), as decimal (**) format 0 representation of internal IEEE float, with leading *space*). | 19 |
| 11 | **Thermal Update Scan Interval** (in seconds) as decimal (**) integer value. | 1B |
| 31 | **Module hardware version** number in the form e.eeeeee. (9016 returns 'N08' | |
| 32 | **Hardware trigger mode.**<br>0=positive going edge<br>1=negative going edge<br>2=trigger on any edge<br>(9016 returns a 'N08') | 32 |
| 3c | **Temperature Range**, as a hex value<br>0000 = range 0 to 60ºC (default)<br>0006 = range -30 to 60º C<br>0007 = range -20 to 70ºC | |

(+) **NOTE**: This 4-byte hex status fields may also be returned in autonomous data streams, but as pure binary extensions of each stream's packet binary header (see **'c'** command, *ii*=05, *bbbb*=0002).

**Example:**

- Request model number from a **Model 9116** module:

  "**q00**"

  Read response indicating it is a **Model 9116**:

  "**9116**"

- Request TCP back-off delay for a **Model 9116** module:

  **"Q07"**

  Read hex (16-bit binary) response:

  **"001F"** (31 decimal, or 31 x 20=620 µsec.)

## READ HIGH-PRECISION DATA (Command 'r')

**Purpose:** Returns the most recently acquired *engineering-unit* ***pressure*** data for the specified channels. Each datum returned in the response will be in the specified high-precision data format.

| | |
|---|---|
| **Command** | "r***ppppf***"<br><br>'*r*' is the *command* letter<br>'*pppp*' is the *position* field<br>'*f*' is the *format* field |
| **Response** | " ***dddd.. dddd***"<br><br>' *dddd*' are *datum* fields, each with leading ***space*** (except *f*= 7 or 8). |

**Description:** The 4-character hex *position* field (*pppp*) specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right). Models 9021 and 9022 use only channels 12-1.

The 1-character *format* field (*f*) specifies the format of each *data* field (*dddd*) that will be returned in the requested response. **The first datum returned in the response will be for the highest channel number specified.** Each (non-binary) datum will be preceded by a ***space*** character (except in the case of *f*= 7). Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

| ***f*** | **converts each internal response *datum* value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | single binary float | to | 7-10-digit signed decimal " [-xxx]x.xxxxxx" | 13 |
| 1 | single binary float | to | 8-digit hex integer " xxxxxxxx" | 9 |
| 2 | double binary float | to | 16-digit hex integer " xxxxxxxxxxxxxxxx" | 17 |
| 5 | single binary float | to | long integer (EU*1000) then to 8-digit hex integer | 9 |
| 7 | single binary float | to | single binary float (big endian: msb first) | 4 |
| 8 | single binary float | to | single binary float (little endian: lsb first) | 4 |

Unless the EU conversion scalar is altered, the returned data will be in units of psi

**Example:**

- Send TCP/IP command to **Model 9116** module (via its connected socket), that returns decimal pressure data for channels 1, 5, 9, and 13 in ASCII fixed point format:

  "**r11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  "**1.234000   0.989500   1.005390   0.899602**"

## READ TRANSDUCER TEMPERATURE (Command 't')

**Purpose:** Returns the most recently acquired *engineering-unit* ***temperature*** data (in ºC) for the specified channels. Each datum returned in the response will be in the specified high-precision data format.

| | |
|---|---|
| **Command** | "**t*ppppf***"<br><br>'t' is the *command* letter<br>'*pppp*' is the *position* field<br>'*f*' is the *format* field |
| **Response** | " **dddd.. dddd**"<br><br>' *dddd*' are the *datum* fields, each with leading ***space*** (except *f* =7 or 8). |

**Description:** The 4-character hex *position* field (pppp) specifies a 16-bit binary bit-map, with each set bit (1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *data* field (*dddd*) that will be returned in the requested response. **The first datum returned in the response will be for the highest channel number specified.** Each (non-binary) datum will be preceded by a ***space*** character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

| ***f*** | **converts each internal response *datum* value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | single binary float | to | 7-10-digit signed decimal " [-xxx]x.xxxxxx" | 13 |
| 1 | single binary float | to | 8-digit hex integer " xxxxxxxx" | 9 |
| 2 | double binary float | to | 16-digit hex integer " xxxxxxxxxxxxxxxx" | 17 |
| 5 | single binary float | to | long integer (EU*1000) then to 8-digit hex integer | 9 |
| 7 | single binary float | to | single binary float (big endian: msb first) | 4 |
| 8 | single binary float | to | single binary float (little endian: lsb first) | 4 |

**Example:**

- Send TCP/IP command to **Model 9116** module (via its connected socket) that returns decimal temperature data for channels 1, 5, 9, and 13:

  "**t11110**"

  Response contains data (in ºC) for channels 13, 9, 5, and 1 (left to right):

  " **21.234000 20.989500 21.005390 20.899602**"

## READ INTERNAL COEFFICIENTS (Command 'u')

**Purpose:** Returns one (or more contiguous) requested internal coefficient(s) in a specified internal coefficient array, and in the specified response data format.

| | |
|---|---|
| **Command** | "***ufaacc[-cc]***"<br><br>'u' is the *command* letter.<br>'*f*' is the *format* field.<br>'*aa*' is the *array index* field.<br>'*cc[-cc]*' is *coefficient index* [or contiguous *range*]. |
| **Response** | " ***dddd.. dddd***"<br><br>'*dddd*' are the *datum* fields, each with leading ***space*** character. |

**Description:** The 1-character *format* field *(f*) is a single decimal digit that defines the format of each returned datum in the response. All *datum* ( *dddd*) fields returned will be preceded by a *space* character. Most coefficients have a floating point datum type (*f*=0-1), while others have an integer datum type (*f*=5). Requesting an improper format will result in an "***N08***" error response. Valid format types for coefficients are shown in the following table:

| ***f*** | **converts each internal value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | single binary float | to | 7-10-digit signed decimal " [-xxx]x.xxxxxx" | 13 |
| 1 | single binary float | to | 8-digit hex integer " xxxxxxxx" | 9 |
| 5 | long binary integer | to | 8-digit hex integer " xxxxxxxx" | 9 |

The 2-character *array index* field (*aa)* is a **hexadecimal value** selecting a particular internal coefficient array. The first *array index* (aa=01) refers to channel one's transducer, the 16th (aa=10) refers to channel sixteen's transducer. Finally, the last array (aa=11) refers to a special global array.

A single 2- character *coefficient index* field ( *cc*) is a hexadecimal value that selects a particular coefficient within the specified array. Multiple contiguous coefficients of the same type may be specified by using a *coefficient index"range"* specified by adding a hyphen (negative sign) between two such indexes (*cc-cc*).

The coefficients of internal DH200 transducers used in the **Model 9116** are selected with **array indexes** *aa*=01 through 10 (hex). *All* valid *coefficient indexes* (for each of these arrays) are listed in the following table:

Note

**Coefficients used for typical applications are shown in BOLD type. All other coefficients are typically not used outside of advanced diagnostic functions.**

| cc | Transducer Coefficients Description | Datum Type |
|---|---|---|
| 00 | **Re-zero Cal Adjustment** (offset) term | FLOAT |
| 01 | **Span Cal Adjustment** (gain) term | FLOAT |
| 02 | **Dynamic EU Conversion coefficient c0** | FLOAT |
| 03 | **Dynamic EU Conversion coefficient c1** | FLOAT |
| 04 | **Dynamic EU Conversion coefficient c2** | FLOAT |
| 05 | **Dynamic EU Conversion coefficient c3** | FLOAT |
| 06 | Reserved for Factory Use | --- |
| 07 | **User Defined Date field (see end-of-table note)** | INTEGER |
| 08 | Date of Factory Calibration (see end-of-table note) | INTEGER |
| 09 | **Transducer Manufacturing Reference number** | INTEGER |
| 0A | **Transducer Full-Scale Range code (see Appendix F)** | INTEGER |
| 0B-0F | Temperature 1, Pressures 1-5 voltages | FLOAT |
| 10-14 | Temperature 2, Pressures 1-5 voltages | FLOAT |
| 15-19 | Temperature 3, Pressures 1-5 voltages | FLOAT |
| 1A-1E | Temperature 3, Pressures 1-5 voltages | FLOAT |
| 1F-23 | Temperature 5, Pressures 1-5 voltages | FLOAT |
| 24-28 | Temperature 6, Pressures 1-5 voltages | FLOAT |
| 29-2D | reserved for future use (temperature 7) | FLOAT |
| 2E | Temperature 1 Temperature Output voltage at 0 psi | FLOAT |
| 2F | Temperature 2 Temperature Output voltage at 0 psi | FLOAT |
| 30 | Temperature 3 Temperature Output voltage at 0 psi | FLOAT |
| 31 | Temperature 4 Temperature Output voltage at 0 psi | FLOAT |
| 32 | Temperature 5 Temperature Output voltage at 0 psi | FLOAT |

| cc | Transducer Coefficients Description | Datum Type |
|---|---|---|
| 33 | Temperature 6 Temperature Output voltage at 0 psi | FLOAT |
| 34 | (reserved) Temperature 7 Temperature Output voltage at 0 psi | FLOAT |
| 35 | Temp Vs Pressure Correction coefficient (t0) | FLOAT |
| 36 | Temp Vs Pressure Correction coefficient (t1) | FLOAT |
| 37 | Temp Vs Pressure Correction coefficient (t2) | FLOAT |
| 38 | Temp Vs Pressure Correction coefficient (t3) | FLOAT |
| 4D | Pressure Voltage Gain Index | INTEGER |
| 4E | Temperature Voltage Gain Index | INTEGER |
| 5F | Current Calculated Pressure (PSI) | FLOAT |

The **User Defined Date** field (*cc*=07) is also a 32-bit integer which may be encoded in a similar manner. Possible uses are to indicate the date of last user zero and/or span calibration or possibly the date of next required calibration. If this optional field is used, the user is responsible for correctly encoding the date into the appropriate 32-bit integer value. Any modifications of this field (using the ***Download Internal Coefficients*** (‘**v’**) command) will result in the new value automatically being entered to transducer non-volatile memory.

The **Date of Factory Calibration** field (*cc*=08) identifies the date of factory calibration for the DH200 transducer (9116). It is stored internally as a 32-bit integer whose value (viewed as a decimal number) is in the format of yymmdd (year, month, day).

A special single ***Other Coefficients*** array is selected with ***array index aa*=11 (hex).** All the valid *coefficient indexes* (for this array only) are listed in the following table:

| cc | Other Coefficients Description | Datum Type |
|---|---|---|
| 00 | reserved - EU conversion offset term | FLOAT |
| 01 | **EU Pressure Conversion scaler (default=1.0)** | FLOAT |
| 02 | Reserved - EU conversion Non-Linearity term | FLOAT |
| 03 | Reserved-Reference Voltage value | FLOAT |

**Example:**

- Send TCP/IP command to module (via its connected socket) requesting the most recent calibration adjustment's *offset* and *gain* terms (*cc*=00-01), and the adjacent factory-determined transducer coefficients C0 through C4 (*cc*=02-06) for transducer 1: Data requested in ASCII-hex format representing the internal binary floating point format.

  "**u10100-06**"

  Response returned is:

  " **3B200A6E . .   00000000**"

Note

| |
|---|
| **The maximum response size is 300 characters. If the requested range of coefficients requested exceeds this, the module will return an "N07" error response.** |

## DOWNLOAD INTERNAL COEFFICIENTS (Command 'v')

**Purpose:** Downloads one or more internal coefficients to the module.

| | |
|---|---|
| **Command** | ""***vfaacc[-cc]dddd..dddd***"<br><br>'v' is the *command* letter.<br>'*f*' is the *format* field.<br>'*aa*' is the *array index* field.<br>'*cc[-cc]*' is coefficient index [or contiguous range].<br>'*dddd*' are the *datum* field(s) each with a leading ***space***. |
| **Response** | "**A**"<br>'A' is the *acknowledge* letter |

**Description:** The 1-character *format* field (*f*) is a single decimal digit that defines the format of each coefficient to be downloaded in the command's datum ( *dddd*) fields, with each datum preceded by a ***space*** character. Most coefficients have a floating point datum type (*f*=0-1), while others have an *integer* datum type (*f*=5). Sending a datum in the improper format will result in an "**N08**" error response. Valid format types are shown in the following table:

| ***f*** | **converts each internal value from . . .** | | | **max. char.** |
|---|---|---|---|---|
| 0 | 1-10-digit signed decimal " [-xxx]x.[xxxxxx]" | to | single binary float | 13 |
| 1 | 8-digit hex integer " xxxxxxxx" | to | single binary float | 9 |
| 5 | 8-digit hex integer " xxxxxxxx" | to | long binary integer | 9 |

The 2-character *array index* field (*aa*) is a **hexadecimal value** selecting a particular internal coefficient array to receive the downloaded data. The first *array index* (aa=01) refers to channel 1's transducer, the 16th (aa=10) refers to channel 16's transducer. Finally, the last array (aa=11) refers to a special global array.

A single 1- or 2- character *coefficient index* field (c or cc) is a hexadecimal value that selects a particular coefficient within the specified array. Multiple contiguous coefficients may be specified by using a *coefficient index "range"* specified by adding a hyphen (negative sign) between two such indexes.

The coefficients of internal DH200 transducers used in the **Model 9116** are selected with **array indexes** *aa*=01 through 10 (hex). *All* valid *coefficient indexes* (for each of these arrays) are listed in the following table:

| cc | Transducer Coefficients Description | Datum Type |
|---|---|---|
| 00 | **Re-zero Cal Adjustment** (offset) term **(Note 1)** | FLOAT |
| 01 | **Span Cal Adjustment** (gain) term **(Note 2)** | FLOAT |
| 07 | User Defined Field **(Note 4)** | INTEGER |
| 09 | Transducer Manufacturing Reference Number **(Note 5)** | INTEGER |
| 0A | Transducer Full-Scale Range Code (See Appendix F) **(Note 5)** | INTEGER |

**(Note 1)** Related command '***w08***' can be used to download the offset term to the sensor's non-volatile memory (digitally or non-digitally compensated sensor).

**(Note 2)** Related command '***w09***' can be used to download the gain term to the sensor's non-volatile memory (digitally or non-digitally compensated sensor).

**(Note 4)** Data is immediately stored to the sensor's non-volatile memory.

The **User Defined Date** field (*cc*=07) is a 32-bit integer. Possible uses are to I ndicate the date of last user zero and/or span calibration or possibly the date of next required calibration. If this optional field is used, the user is responsible for correctly encoding the date into the appropriate 32-bit integer value e.g., a decimally encoded 'yymmdd' date. Any modifications of this field (using the ***Download Internal Coefficients*** ('**v'**) command) will result in the new value automatically being entered to transducer non-volatile memory.

A special single ***Other Coefficients*** array is selected with ***array index aa*=11 (hex).** All the valid *coefficient indexes* (for this array only) are listed in the following table:

| cc | Other Coefficients Description | Datum Type |
|---|---|---|
| 01 | EU **Pressure** Conversion scaler (default=1.0) | FLOAT |

**Example:**

- Send TCP/IP command to module (i.e., via its connected socket): with replacement values for the channel's offset and gain correction terms loaded into the module's volatile memory (*cc*=00-01). Load these into channel # 8's ***Transducer Coefficient*** array (*aa*=08).

  "**v00800-01 0.000 1.000**"

  Response returned is:

  "**A**"

- Send command to **Model 9116** module (via its connected socket) to change its default EU output from psi to kPa. This will be done by changing the EU **Pressure Conversion Scaler** to 6.894757.

  "**v01101 6.894757**"

  Response returned is

  "**A**"

## SET/DO OPERATING OPTIONS/FUNCTIONS (Command 'w')

**Purpose:** Change a module's default operating option settings, or invoke special internal operations or functions.

| | |
|---|---|
| **Command** | "***wii[dd[ eeee]]***"<br><br>'w' is the *command* letter.<br>'*ii*' is the *option index* field.<br>'*dd*' is an [optional] hex *datum* field.<br>'*eeee*' is an [optional] extra datum with a leading ***space*** character. |
| **Response** | "**A**"<br>'A' is the *acknowledge* letter |

**Description:** The *index* field *(ii)* contains two hex digits that identify the specific option to be set or function to be performed. The *datum* field *(dd)*, when present, contains 2 hex digits. A few indexes also require an *extra datum* field *(eeee)*. Valid options/functions are listed in the table below (-- marks a missing *datum* field in its column, and fourth column shows any **'q'** command index that reads same option):

| ii | dd | Description | 'q' read index |
|---|---|---|---|
| 00 | --- | Execute **Internal Self Test**. | |
| 01 | --- | Update **Internal Thermal Coefficients**. | |
| 02-06 | --- | Reserved for factory use | |
| 07 | --- | Store **Operating Options** in non-volatile flash memory. | |
| 08 | --- | Store **Current *Offset* Terms i**n transducers' non-volatile memories. | |
| 09 | --- | Store **Current *Gain* Terms** in transducers' non-volatile memories. | |
| 0A | 01-10 | Set **Number of Channels in Module** (default =16 for 9116). | |
| 0B | 00<br><br>01 | Enable **Automatic Shifting of Calibration Valve** during ***Calculate and Set Offsets*** (**'h'**) command (default).<br>Disable **Automatic Shifting of Calibration Valve** in **'h'**. User will manually control calibration value. | |

| ii | dd | Description | 'q' read index |
|---|---|---|---|
| 0C | 00<br><br>01 | **Set Cal Valves to RUN or LEAK Position** (default) — choice made by *ii*=12.<br>**Set Cal Valves to CAL/RE-ZERO or PURGE Position** — choice made by *ii*=12. | 0B<br>**see chart below** |
| 0D-0E | -- | Reserved for factory use | |
| 0F | 00<br>01 | Disable periodic **Thermal Coefficient Update** task.<br>Enable periodic **Thermal Coefficient Update** task (default). | |
| 10 | 01-20 | Set **Number of A/D Samples to Average, (default = 8).** Valid values are 4, 8,16, 32, and 64. Other values below 64 are rounded up to the next valid value listed above. | 05 |
| 11 | -- | Reserved for factory use | |
| 12 | 00<br><br>01 | **Set Cal Valves to RUN or CAL/RE-ZERO Position** (default) — choice made by *ii*=0C.<br>**Set Cal Valves to PURGE or LEAK Position** — choice made by *ii*=0C. | 0B<br>**see chart below** |
| 13 | 00<br>01 | Use **Static IP Address Resolution** (default)<br>Use **Dynamic IP Address Resolution** (**RARP/BOOTP)** (Results in immediately becoming the module's new power-on default) | 06 |
| 14 | 00<br>01<br><br><br>02 | Disable **Host Response/Stream Back-Off Delay** (default).<br>Enable **Host Response/Stream Back-Off Delay** as low-order byte of Ethernet Address(converted to decimal value * 20 □sec.).<br>Enable **Host Response/Stream Back-Off Delay** specified per ***eeee*** as decimal value (* 20 □sec.) | 07 |
| 16 | 00<br><br>01 | Disable **Host Response/Stream Total Size Prefix** (default).<br>Enable **Host Response/Stream Total Size Prefix** (2-byte big-endian binary value with total size of response or stream data in bytes that follows it). | 08 |
| 17 | 00 | Set **TCP Connect Port** per ***eeee*** as decimal value (default=9000). | 09 |
| 18 | 00<br>01 | Disable **Auto UDP Broadcast at Reset** (default).<br>Enable **Auto UDP Broadcast at Reset**. | 0A |
| 19 | 00<br><br>01 | Set **Minimum Temperature Alarm Set Point** (in $^{N}$C) per ***eeee*** as decimal value (default = 0 $^{N}$C).<br>Set **Maximum Temperature Alarm Set Point** ( in $^{N}$C) per ***eeee*** as decimal value (default = 60 $^{N}$C). | 0D<br><br>0E |
| 1B | 00 | Set **Thermal Update Scan Interval** per ***eeee*** as decimal value (seconds), 1 <= ***eeee*** <= 3600 seconds (default = 15). | 11 |

| ii | dd | Description | 'q' read index |
|---|---|---|---|
| 31 | 00 | Set module type alias. [1] eeee=9116 (default) or 9016 | 00 |
| 32 | dd | Set hardware trigger mode. [2]<br>dd=00 trigger on positive going edge (default)<br>dd=01 trigger on negative going edge<br>dd=02 trigger on any edge (duty cycle must be taken into account in order to avoid over-triggering) | 32 |
| 3c | 00<br>06<br>07 | Set temperature range = 0 to 60ºC (default)<br>Set temperature range = -30 to 60ºC<br>Set temperature range = -20 to 70ºC | |

1. The set module type alias command instructs the 9116 to identify itself as a 9016 in response to the 'psi9000' UDP broadcast command, the UDP startup broadcast messages, and in response to the q0 command. This command is provided in support of legacy software. Valid command responses are; 'A' - acknowledge, 'N08' - invalid command (9016s always return'N08'), and 'N07' - invalid alias type. The module type alias setting can be made nonvolatile with the 'w07' command.

2. The Set hardware trigger mode is always volatile and will be set to the default upon any interruption of power. Valid command responses are; 'A' - acknowledge and 'N08' - invalid command (9016s always return 'N08').

Modification of option 13 hex results in the new option selection becoming the module's new power-on default. All other options must be stored in non-volatile flash memory using '***w07***' command in order to be retained after the module power cycles.

The Valve Position indexes (*ii*=12 and *ii*=0C) each have two states (00/01) that when combined provide four (4) possible states of the C1/C2/C3/C4 internal valves. This "Logical Rotary Switch" with four (4) positions is summarized in the following chart:

| | C1 Energized<br>C2 Not<br>(0C=01) | C2 Energized<br>C1 Not<br>(0C=00) |
|---|---|---|
| C3 Energized<br>C4 Not<br>(12=01) | **PURGE position** | **LEAK/CHECK position** |
| C4 Energized<br>C3 Not<br>(12=00) | **CAL/RE-ZERO position** | **RUN position** |

**Example:**

- Send TCP/IP commands to **Model 9116** module (via its connected socket) setting the calibration valve to the **CAL** (or **Re-Zero**) position:

  "**w1200"** (Set **RUN/CAL** valve position)
  "**w0C01**" (Set **CAL** position)

  Responses (both commands):

  **"A"**
  **"A"**

**Note**

If the programmer "knows" that the module is already in the **RUN/CAL** valve mode, the first command above is optional. For more information, see **Figures 4.1** through **4.4** in **Chapter 4**.

## NETWORK QUERY (UDP/IP Command 'psi9000')

**Purpose:** To determine how many (and which) modules are powered-up and operational on the network.

| | |
|---|---|
| **Command** | "psi9000" |
| **Response** | "*ipadr, ethadr, sernum, mtype, sfwver, connst, ipadrst, lisport, subnet, iparpst, udpast, pwrst,"* |

**Description:** When a module receives this broadcast command (by continuously monitoring port 7000) it responds with a broadcast (on port 7001) with an ASCII response containing comma-separated parameters. These are listed in the following table:

| Parameter | Meaning |
|---|---|
| *ipadr* | IP address |
| *ethadr* | Ethernet address |
| *sernum* | Serial number |
| *mtype* | Module type (e.g., **Model 9116**) |
| *sfwver* | Software version (e.g., x.xx decimal format) |
| *connst* | Connection status (1=connected, 0=available) |
| *ipadrst* | IP address status (1=has one, 0=waiting for server) |
| *lisport* | IP listening port for connections (default=9000) |
| *subnet* | Subnet mask |
| *iparpst* | IP address resolution status (1=uses RARP/BOOTP server, 0=uses static IP address stored internally) |
| *udpast* | UDP auto status (1=broadcasts this response automatically after connection possible, 0=only sends response for "psi9000" UDP/IP command. |
| *pwrst* | Power-up status (same as a 'q02' command response) |

Some special rack-mounted module types (e.g., 9816) also add rack, cluster, and slot parameters to the response above. These additional parameters are added following the '***pwrst***' parameter.

This uniform network query response allows a client host program to identify, configure, and use any suitable group of modules (for the task at hand) by simply opening a TCP/IP connection between itself and each available module needed.

**Example:**

- Query all module(s) on the network.

  **"psi9000"**

  Response(s):

  **200.201.7.207, 0-e0-8d-1-7-cf, 1999, 9116, 2.32, 0, 1, 9000, 192.0.0.0, 0, 1, 0x0**

## RE-BOOT MODULE (UDP/IP Command 'psireboot')

**Purpose:** To unconditionally "reboot" a specified module.

| | |
|---|---|
| **Command** | **"psireboot *ethadr*"**<br>where *ethadr* is the Ethernet address of the specified module in the following special hex-digit format<br>'xx-xx-xx-xx-xx-xx' |
| **Response** | none (module reboots) |

**Description:** When a **Model 9116** module receives this broadcast command, (by continuously monitoring port 7000) it responds by immediately restarting its firmware. The result is essentially the same as a power-up restart, in that any TCP/IP connection is lost, and the module returns to its normal startup state. The host must wait long enough for the re-boot process to be completed before it can again request a connection to the module.

**Example:**

- Re-boot a specified module on the network.

  **"psireboot 00-E0-8D-00-00-01"**

  Response:

  **(None)**

## CHANGE MODULE'S IP ADDRESS RESOLUTION METHOD & RE-BOOT (UDP/IP Command 'psirarp')

**Purpose:** To change (toggle) the current IP address resolution state (*ipaarpst*) of a specified module, and then unconditionally "re-boot" it.

| | |
|---|---|
| **Command** | **"psirarp *ethadr*"**<br>where *ethadr* is the Ethernet address of the specified module in the following special hex-digit format<br>'xx-xx-xx-xx-xx-xx' |
| **Response** | none (module re-boots) |

**Description:** When a **Model 9116** module receives this broadcast command, (by continuously monitoring port 7000) it responds by toggling its current ARP method to one of two states: dynamic resolution or static resolution. Then it restarts its firmware. The result is essentially the same as a power-up restart, in that any TCP/IP connection is lost, and the module returns to its normal startup state. However, if it used the static resolution method before it received this command, after the re-boot, it will not have a valid IP address until an external network server (RARP or BOOTP) provides it with one. However, executing the command a second time will restore it to using its original statically-assigned IP address (after another re-boot finishes).

Just as for the "psireboot" command, the host must wait long enough for the re-boot process to be completed before it can again request a connection to the module.

**Example:**

- Reconfigure a specified module on the network so that it uses its "other" IP address resolution method, and also re-boot it. Presumably, the host knew the module's current state (*iparpst*) as a result of a recent Network Query response from the module.

  **"psirarp 00-E0-8D-00-00-01"**

  Response:

  (**None**)

# Chapter 4

# Calibration

## 4.1 Introduction

Each internal DH200 transducer in a **Model 9116** Intelligent Pressure Scanner contains non-volatile read/write memory capable of storing the transducer's full thermal and pressure calibration data.

The **Model 9116** Intelligent Pressure Scanner module uses a third-order polynomial to convert transducer output voltage to pressure. All calculations are carried out internally using high precision math. The following formula is used for all pressure output calculations.

$$P_T(V) = [C_0(T) + C_1(T)*V + C_2(T)*V^2 + C_3(T)*V^3] * C_{SPAN} - C_{RZ}$$

where:

$P_T$ = Calculated applied pressure

$V$ = Transducer output voltage

$C_0(T)$ .. $C_3(T)$ = Conversion coefficients generated from calibration data at temperature T.

$C_{RZ}$ = Re-zero adjustment's "*offset*"correction coefficient

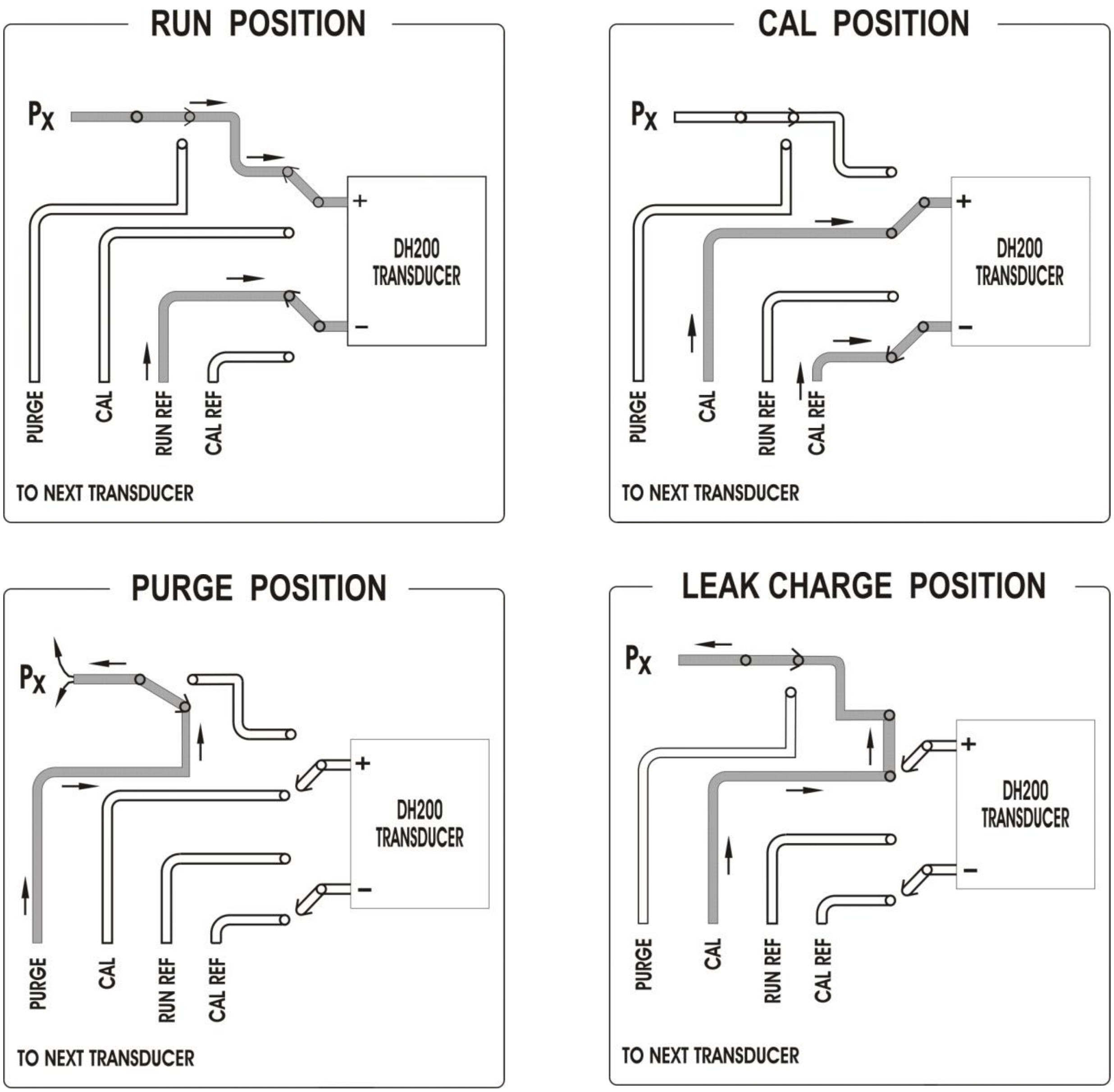
$C_{SPAN}$ = Span adjustment's "*gain*" correction coefficient

Since the polynomial's coefficients are a function of the current temperature, they are dynamically re-calculated by the module firmware (with other equations) to compensate for each transducer's measured temperature change.

Each **Model 9116** Intelligent Pressure Scanner contains an integral purge/leak check calibration manifold. Through software commands, this valve may be placed in one of four positions: **RUN, CAL, PURGE,** or **LEAK-CHARGE**. (See the ***Set/Do Operating Options/Functions*** **('w')** command (*ii*=0C & 12) in **Chapter 3**, and in particular the **Valve Position Chart** at the end of command's description.) When each module's internal calibration valve is placed in the **CAL/RE-ZERO** position (through software commands), all DH200 transducer *pressure* inputs are pneumatically connected to the **CAL** input ports. All DH200 *reference* inputs are pneumatically connected to the **CAL REF** input port. The **CAL** input may be used to perform on-line zero adjustment of the 9116's transducers. This capability virtually eliminates sensor zero drift error and ensures the highest possible data accuracy. The **CAL** input may also be used for DH200 span adjustment calibrations. Span calibration of multi-range scanners may also utilize the **CAL** input ports if the highest applied pressure does not exceed the proof pressure rating of any installed transducer.

For reference when operating the **Model 9116** calibration manifold, **Figures 4.1** through **4.4** show simplified pneumatic diagrams of the calibration manifold in its various positions.

> **Note:** **Periodic zero and span calibration should be the only calibration required to maintain specified performance throughout the life of the scanner.**




**Figures 4.1 – 4.4**
**Pneumatic Diagrams of the Calibration Manifold**

# 4.2 Re-zero Calibration

All **Model 9116** Intelligent Pressure Scanners are capable of independently performing a transducer calibration adjustment function, referred to as *Re-zero adjustment* (or simply Re-zero Cal). The Re-zero calibration will result in a recalculated "offset" coefficient for each channel being calibrated, which automatically compensates for any transducer offset drift errors. Since the factory-set coefficients in each transducer (that characterize both pressure and temperature) are extremely stable over time, these simple offset corrections compensate for the majority of transducer errors over time. For this reason, a Re-zero may be the only calibration adjustment required by many applications. For those applications requiring more accuracy, an optional single-point Span-only calibration adjustment will be described in **Section 4.3**. An improved multi-point calibration adjustment, integrating both the Re-zero and Span calibration process will be described in **Section 4.4**.

For **Model 9116**, with integral DH200 pneumatic transducers, internal manifolds and valves allow a Re-zero calibration to be accomplished easily and automatically.

When instructed to execute a ***Calculate and Set Offsets*** (**'h'**) command, the **NetScanner™ System** module will automatically perform the *Re-zero adjustment* calibration, and then update the *offset coefficients* in its volatile memory. It will subsequently use the newly calculated terms for all future engineering-unit calculations until power is lost to the module.

**Note**

**When using the *Calculate and Set Offsets* command ('h'), only local terms in the module's volatile main memory (RAM) are updated. Under normal operation, it is not recommended to store these new coefficients in transducer non-volatile memory. Instead, the re-zero should be performed at regular intervals..**

## 4.2.1. Re-zero Calibration Valve Control

When instructed to execute a Re-zero (***Calculate and Set Offsets*** (**'h'**)) command, **Model 9116** modules will normally shift the internal calibration valve into the **CAL** position and use the pressures present at the **CAL** and **CAL REF** inputs for the "minimum" (e.g., zero) calibration pressure. After the Re-zero adjustment is complete, the **Model 9116** calibration valve will be placed in the **RUN** position. This automatic shift of the calibration valve can be disabled through use of the ***Set Operating Options*** (**'w'**) (option index=0B hex) command. This allows independent control of the calibration valve by the user using other options (see *option indexes* = 0C and 12 hex) of the same command.

### 4.2.2 Re-zero Calibration Summary

Following is a simple, step-by-step procedure for executing a Re-zero calibration of a **Model 9116** Intelligent Pressure Scanner. Optional commands are shown within brackets [ ].

| Description | Model 9116 Command |
|---|---|
| Disable automatic valve shifting after module power up.<br>Ensure valves in **RUN/CAL** mode (default) | [w0B01]<br>[w1200] |
| … normal data acquisition | |
| Apply 0.0 psi differential to the module **CAL** and **CAL REF** inputs. | |
| Place the module calibration manifolds into the **CAL** position [if w0B01 command executed in Step 1] | w0C01 |
| Delay for settling of pneumatic inputs | |
| Verify that measured data reads near expected zero value | [rFFFF0] |
| Instruct module to calculate new *offset* coefficients for all 16 channels of **Model 9116** | hFFFF |
| Place calibration manifold back into the **RUN** position [if w0B01 command executed in Step 1] | [w0C00] |
| Store new *offset* coefficients to transducer nonvolatile memory | [w08] |
| … continue normal data acquisition | |

## 4.3 Span Calibration

For improved accuracy, **Model 9116** Intelligent Pressure Scanners are capable of independently performing a transducer calibration function, referred to as *Span adjustment* (or simply Span Cal). Actually, there is a provision to supply any suitable "upscale" pressure (e.g., actual transducer full-scale) during such a calibration adjustment. The *Span adjustment* calibration will result in a recalculated "gain" coefficient for each channel being calibrated, to compensate for any transducer or module gain errors. For best results, a Re-zero calibration should be performed before performing a span calibration. Also, note that a new and improved **Multi-Point Calibration** function exists. This function integrates the separate calibration functions (for Re-zero and Span adjustment described in **Section 4.2** and this section) into a single function that adjusts both "offset" and "gain" coefficients at the same time, using two **or more** calibration points. Details of using this improved calibration function are described in **Section 4.4.**

For **Model 9116**, with integral DH200 transducers, internal manifolds and valves allow a Span adjustment pneumatic calibration to be accomplished easily and automatically.

It is recommended that a *Span adjustment* be performed whenever new transducers are installed in the instrument. In such cases, the new *gain* coefficients that result should always be stored back into the transducer's non-volatile memory. In other cases, the user's application may not require periodic span adjustment since the other factory-determined pressure/temperature coefficients (stored permanently inside each transducer) are extremely stable. Only an occasional *Re-zero adjustment* may be all that is necessary.

When instructed to execute a ***Calculate and Set Gains*** (**'Z'**) command, the module will perform the *Span adjustment* calibration, and then update the *gain coefficients* in its memory. It will subsequently use the newly calculated *gain* terms for subsequent engineering-unit calculations until power is lost to the module.

Note

**When using the *Calculate and Set Gain* ('Z') command, only the local variables in the module's volatile main memory (RAM) are changed.**

### 4.3.1. Span Calibration Valve Control

Before executing a Span adjustment (***Calculate and Set Gains*** (**'Z'**) command), the **Model 9116** modules should have their calibration manifold valve placed in the proper position. For single pressure range units the **CAL** position should be used since the span calibration pressure can be applied between the **CAL** and **CAL REF** ports. Since the module will not attempt to shift this valve automatically, as it does for Re-zero adjustment, it should ***manually*** be placed in the desired position with the ***Set Operating Options*** (**'w'**) command (option indexes = 0C and 12).

When span calibrating **Model 9116** modules with multiple ranges installed, the **CAL** port may be used to apply pressure to all transducers **only if the specified proof pressure is not exceeded on any channel**. Refer to ***Calculate and Set Gains*** ('**Z**') command to specify the channels to be affected by the command in a multi-range unit. If the application of a specific span pressure exceeds the proof pressure rating of any other transducer contained within the same scanner, the calibration pressures must be applied to the **RUN** side pneumatic input ports. Since the calibration command (**'Z'**) has a *channel selection bit map* parameter allowing it to calibrate only the desired pressure channels, the **RUN** port is a viable option for supplying the calibration pressures.

### 4.3.2. Span Calibration Summary

Following is a simple, step-by-step procedure for executing a "full scale" span calibration of a 9116 Intelligent Pressure Scanner. It is assumed that all channels in the unit are of the same full scale pressure range. Optional commands are shown within brackets [ ].

| Description | Model 9116 Command |
|---|---|
| Ensure that valves are in **RUN/CAL** mode (default) | [w1200] |
| … normal data acquisition | |
| Perform Re-zero calibration | **See Section 4.2.2** |
| Place the module calibration manifolds into the **CAL** position if this is the desired pressure application input. The **RUN** position may be a better choice for modules with transducers having different ranges. | [w0C01] for **CAL**<br><br>[w0C00] for **RUN** |
| Apply exact full scale pressure to appropriate module **CAL** and **CAL REF** inputs [or optionally to **RUN** inputs]. | |
| Delay for settling of pneumatic inputs | |
| Verify that measured data reads near expected full scale | [rFFFF0] |
| Instruct module to calculate new gain coefficients for all 16 channels | ZFFFF |
| Place calibration manifold back into the RUN position | w0C00 |
| Store new gain coefficients to transducer non-volatile memory | w09 |
| … continue normal data acquisition | |

Following is a simple, step-by-step procedure for executing a specified-value span calibration of a Model 9116 Intelligent Pressure Scanner. For the purposes of this example, it will be assumed that an upscale pressure of 14.9800 psi is available from a dead weight tester for the calibration of 15 psi internal transducers.  All sixteen channels are 15 psi full scale.

| Description | Model 9116 Command |
|---|---|
| Ensure that valves are in **RUN/CAL** mode (default) | [w1200] |
| … normal data acquisition | |
| Perform Re-zero calibration first | **See Section 4.2.2** |
| Place the module calibration manifolds into the **CAL** position if this is the desired pressure application input. The **RUN** position may be a better choice for modules with transducers having different ranges. | [w0C01] for **CAL**<br>[w0C00] for **RUN** |
| With a deadweight tester, apply 14.9800psi to the appropriate module **CAL** and **CAL REF** inputs [or optionally to **RUN** inputs] | |
| Delay for settling of pneumatic inputs | |
| Verify measured data reads near expected full scale | [rFFFF0] |
| Instruct module to calculate new gain coefficients for all 16 channels | ZFFFF 14.98 |
| Place calibration manifold back into the RUN position | w0C00 |
| Store new gain coefficients to transducer non-volatile memory | w09 |
| … continue normal data acquisition | |

# 4.4 Integrated Multi-Point Calibration Adjustment

**Model 9116** Intelligent Pressure Scanners may have their accuracy enhanced by regular application of one or both of the individual *Re-zero* and *Span* calibration adjustment functions already described in **Sections 4.2** and **4.3**. An integrated and more comprehensive **Multi-Point Calibration** function may be used instead to adjust the same *offset* and *gain* coefficients for a module’s channels. This function also provides for supplying additional calibration points, which is particularly useful when it is desired to fit the adjustment data to the entire negative and positive range of the module. This integrated calibration adjustment function is fully described in this section. It is implemented by four (4) sub-commands of the **‘C’** command. Since this function combines the functions of the Re-zero and Span calibration adjustments (using the **‘h’** and **‘Z’** commands) it is recommended that you read the information of **Section 4.2** and **4.3** before attempting to perform this multi-point calibration.

It is recommended that a **Multi-Point Calibration** *adjustment* be performed whenever new transducers are installed in your module. In such cases, the new *zero* and *gain* coefficients that result should always be restored into the transducer’s non-volatile memory afterwards. In some cases, the user’s application may not require such a comprehensive adjustment as the other factory-determined pressure/temperature coefficients (stored permanently inside each transducer) are extremely stable. Only an occasional *Re-zero adjustment* may be all that is necessary.

When instructed to execute a particular sequence of sub-commands of the ***Configure Multi-Point Calibration*** (**‘C’**) command, the module will perform the various stages of the *Multi-Point Calibration adjustment* calibration function, and then update both the *offset and gain coefficients* in the module’s volatile (e.g., RAM) memory. The module will use this newly calculated data term for all subsequent engineering-unit calculations.

## 4.4.1. Multi-Point Calibration Valve Control

Before executing a **Multi-Point Calibration** adjustment (using various forms of the ***Configure/Control Multi-Point Calibration*** (**‘C’**) command), **Model 9116** modules should have their calibration valve placed in the proper position. For modules with only one common pressure range for its transducers, the **CAL** position should be used since the span calibration pressure can be applied between the **CAL** and **CAL REF** ports (see **Section 4.3.1** for more information on these ports). Since the module will not attempt to shift this valve automatically, as it does for Re-zero adjustment, it should be placed in the desired position ***manually*** with the ***Set Operating Options*** (**‘w’**) command (option indexes = 0C and 12). This is illustrated in the example of the next section.

**Note**

**When using the *Configure/Control Multi-Point Calibration* (‘C’) command, only the local variables in the module’s volatile main memory (RAM) are changed.**

When multi-point calibrating **Model 9116** modules with *multiple ranges* installed, the **CAL** port may be used to apply pressure to all transducers **only if the specified proof pressure is not exceeded on any channel.** If the application of a specific span pressure exceeds the proof pressure rating of any other transducer contained within the same scanner, the calibration pressures must be applied to the **RUN** side pneumatic input ports. Since the calibration

command (**'C'**) has a *channel selection bit map* parameter allowing it to calibrate only the desired pressure channels, the **RUN** port is a viable option for supplying the calibration pressures.

### 4.4.2 Multi-Point Calibration Summary

Following is a simple step-by-step procedure for executing a "multi-point" calibration of a **Model 9116** Intelligent Pressure Scanner. It is assumed that all channels in the unit have the same full-scale pressure range. Optional commands are shown within brackets [ ]. Should it become necessary to abandon this calibration procedure once it is started, you may execute the Abort sub-command ['***C 03***'] of '**C**' at any time after the first '**C**' sub-command.

| Description | Model 9116 Command |
|---|---|
| Ensure that valves in **RUN/CAL** mode (default). | [w1200] |
| … normal data acquisition assumed to be running | |
| Place the module calibration manifolds into the **CAL** position if this is the desired pressure application input.<br><br>The **RUN** position may be a better choice for modules with transducers having different ranges. | [w0C01] for **CAL**<br><br>[w0C00] for **RUN** |
| Ready the module for multi-point calibration by executing the Configure & Start ('*00*') sub-command of 'C'. This establishes all the channels to be affected, and determines the total number of calibration points that will be supplied (3 in this example) in later steps. It also starts module averaging for calibration (64 samples in this example). The linear fit (1) is required. | C 00 FFFF 3 1 64 |
| Apply 1st calibration pressure to the module's **CAL** or **RUN** inputs. The zero (0.0) point is assumed in this case. | |
| After applying zero pressure verify that this pressure is measured correctly by the module. | [rFFFF0] |
| When the data are stable, enter the ***Collect Data*** ('*01*') sub-command of '**C**' specifying this first calibration point (1) with zero pressure (0.0). | C 01 1 0.0 |
| Apply 2nd calibration pressure to the module's **CAL** or **RUN** inputs. A full-scale (+5 psi) point is assumed in this case. | |

| | |
|---|---|
| Verify that pressure reads correctly. | [rFFFF0] |
| When the data are stable, enter another ***Collect Data*** ('*01*') sub-command of '**C**' specifying this second calibration point (2) with 5.0 psi pressure. | C 01 2 5.0 |
| Apply 3rd calibration pressure to the module's **CAL** or **RUN** inputs. A mid-scale negative (-2.5 psi) point is assumed in this case. A vacuum pump is normally required to achieve such a pressure with 903x calibrators. | |
| Verify that measured pressure reads correctly. | [rFFFF0] |
| When the data are stable, enter last ***Collect Data*** ('*01*') sub-command of '**C**' for this point (3) with a negative (-2.5 psi) pressure. | C 01 3 -2.5 |
| Now that data have been collected for every point originally specified, calculate and apply the new coefficient data with a ***Calculate and Apply*** ('*02*') sub-command of '**C**'. This also restores the module to using its original averaging parameters that existed before the first '**C**' command. | C 02 |
| Place calibration manifold back into the **RUN** position, if the **CAL** position was used. | [w0C00] |
| Store new *offset* and *gain* coefficients into transducer non-volatile memory. | w08<br>w09 |
| … continue normal data acquisition. | |

# 4.5 Coefficient Storage

The various calibration functions described in **Sections 4.2** through **4.4** update the active *offset* and *gain* coefficients, respectively, in the module's volatile main memory (RAM) only. These newer calibration coefficients will be lost when instrument power is turned off. The ***Set/Do Operating Options*** (**'w'**) command may be used to also store these coefficients back in each transducer's nonvolatile memory. This command's *option index* = 08 will store new *offset* coefficients, while its *option index* = 09 will store new *gain* coefficients.

A user may read (and should verify) any new *offset* and/or *gain* coefficients after performing each calibration adjustment command (i.e., by saving coefficient data returned in a command **'h'** or **'Z'** response), or the ***Read Internal Coefficients*** (**'u'**) command may be used to read them any time after calibration adjustment commands have been performed (see coefficient indexes *cc*=00 and 01 for arrays *aa*=01 through 10). These "adjusted" coefficients may be verified, and then saved by storing them in each transducer's non-volatile memory with the **'w'** command described above.

Alternately, they may be verified and stored on the host computer’s secondary storage, and later restored (if necessary) with the ***Download Internal Coefficients*** **(‘v’)** command (same array/coefficient indexes as **‘u’**).

# 4.6 Line Pressure Precautions

When operating **Model 9116** pressure scanners at elevated line or reference pressures, care must be taken when any command is issued that may result in shifting of the calibration valve. The user must ensure that any valve shifts will not result in the internal DH200 transducers being exposed to pressure transients that may exceed the proof pressure rating of the transducer. This is especially important when operating at elevated reference pressures as a shift to the **CAL** position may result in a rapid pressure change if the **CAL/CAL REF** pressure varies greatly from the measurement reference pressure.

Chapter 5

# Service

## 5.1 Maintenance

This section provides a detailed step-by-step guide for performing repair and maintenance of **Model 9116** Intelligent Pressure Scanners. The method for upgrading module firmware is also presented in **Section 5.2**.

**Figure 5.1** is an exploded view of the **Model 9116**. Please refer to this drawing for an understanding of the construction of Intelligent Pressure Scanners models. **Figure 5.1a** depicts the 9116 top plate.

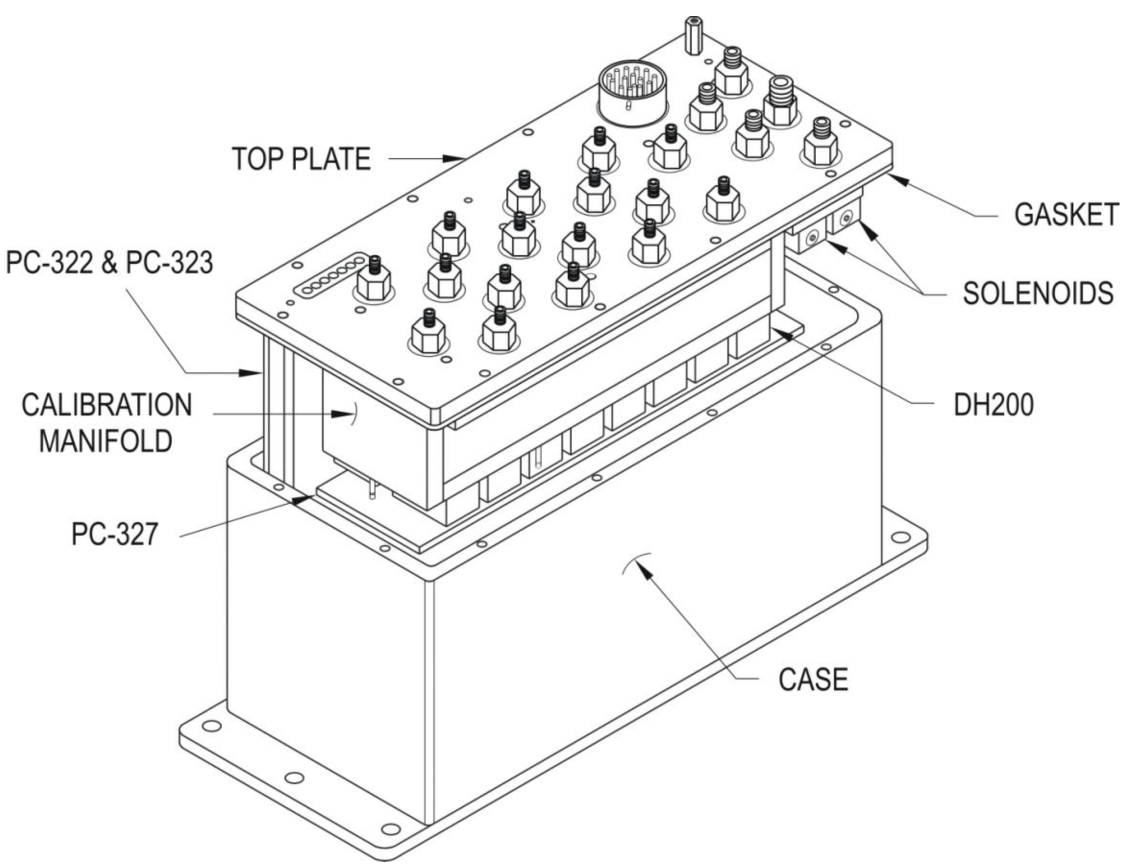



**Figure 5.1**
**Exploded View of Model 9116**

**Note**

**It must be emphasized that printed circuit boards in Model 9116 module are field *replaceable*, but are NOT field *repairable*.**

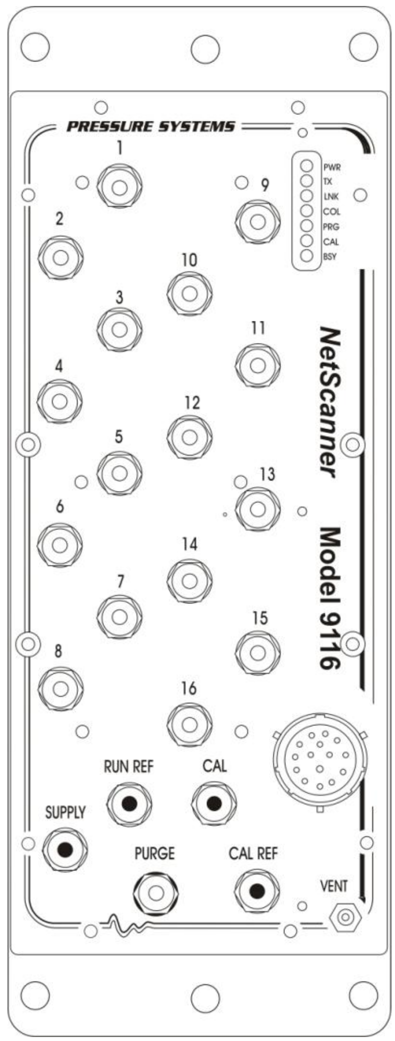



**Figure 5.1a**
**Model 9116 Top Plate**

**Table 5.1** provides a convenient cross reference summary of the components found in your **Model 9116** Intelligent Pressure Scanner. This may be used as a guide to identify the appropriate component replacement sections in this chapter.

**Table 5.1**
**Component Cross Reference**

| Component | Section |
|---|---|
| PC-322 Main Board PCB Assembly | 5.1.3.3 |
| PC-323 PowerPC daughterboard PCB Assembly | 5.1.3.1 |
| PC-327 Analog PCB Assembly | 5.1.3.2 |
| Internal Pneumatic Calibration Manifold | 5.1.6 |
| Internal Solenoid Valves | 5.1.5 |
| Internal DH-200 Transducer | 5.1.4 |

### 5.1.1 Common Maintenance

Your **Model 9116** Intelligent Pressure Scanner is designed for rugged use. No special preventive maintenance is required, although periodic maintenance may be required to replace worn or damaged components. Upgrades or modifications of module hardware or firmware may also be periodically required. For users who wish to do their own maintenance and repairs, maintenance kits and replacement parts for each model may be purchased from the factory.

**All circuit boards are sensitive to electrostatic discharges. Anti-static protection is required whenever the unit is open.**

**When performing any type of maintenance of Model 9116 components, the following guidelines and precautions should always be followed:**

- **Verify that the work area and technicians are properly grounded to prevent damage to electronic components due to electrostatic discharge.**
- **Ensure that all electrical and pneumatic connections have been removed from the module.**
- **Ensure that the work area is free of dust and other possible contaminants that may affect the high tolerance machined parts (and pneumatic seals, if model has an integral manifold).**
- **Care must be taken to prevent contaminants from reaching O-ring surfaces. If O-ring surfaces require cleaning, use a lint-free applicator with acetone to remove dirt and lightly lubricate the O-ring surface with Krytox® provided in the maintenance kit.**
- **Never use sharp objects to cut tubing from the bulged tubes. The tiny scratches left on the tubes could cause leaks.**

In the process of performing general maintenance on a module and in printed-circuit board replacement, the following tools may be required:

- 3/32" and 5/64" Allen-head screwdrivers,
- a 3/16" hex wrench,
- a needle nose tweezers,
- a Phillips-head screwdriver, and
- a small adjustable wrench.

### 5.1.2 Module Disassembly

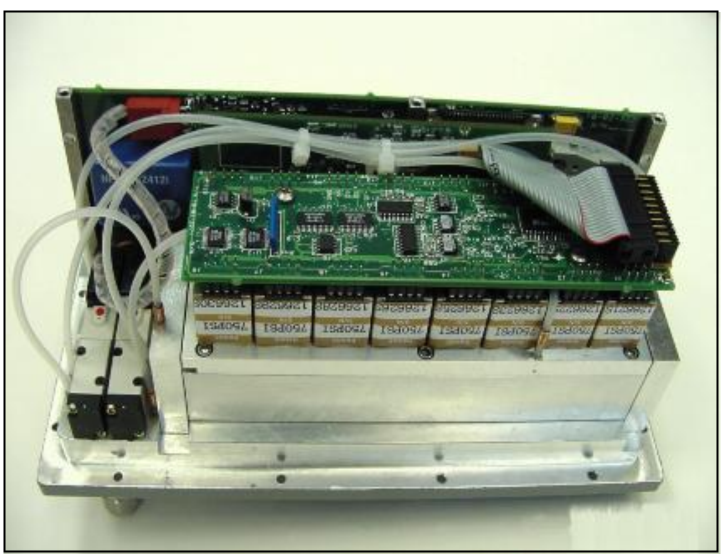
The following procedure should be used to disassemble any model prior to any maintenance.

(1) Place the scanner with its external connectors facing up. With one hand holding the module housing, remove all screws securing the top plate to the module housing. These are located around the outer edge of the top panel of the module housing. The **Model 9116** uses twelve (12) Phillips head screws around the top plate outside perimeter.

(2) When all screws have been removed, gently lift the top panel and attached electronics up and out of the housing. All components of the pressure scanner are attached to the top plate and will lift out of the module housing when the top plate is removed. See **Figure 5.2**. Carefully remove the Viton® gasket with the module top plate. In some cases, it may be easier to hold the top plate and turn the module over, lifting the housing off the top panel.

### 5.1.3 Electronic Circuit Board Replacement

The **Model 9116** contains three (3) printed circuit boards (PCB); the PC-322 main board, the PC-323 PowerPC Daughter board, and the PC-327 analog board. However, the PC-322 and PC323 boards are normally left attached to each other and are treated as a single assembly.



#### 5.1.3.1 PC-327 Analog Board

The following procedures should be used for replacement of the PC-327 Analog Board. Use the tools and follow the general precautions described in **Section 5.1.1**.

(1) Disassemble the module as described in **Section 5.1.2**. Carefully remove the wiring harness from connector P1 of the PC-327 board. Note the orientation of the PC-327 relative to the rest of the module to ensure the new PC-327 is installed in the same position.

(2) Remove the two (2) Phillips-head screws securing the PC-327 board to the DH200 transducers. Carefully disconnect the PC-327 board from the DH200s by slowly working the board off; starting at one end and moving down the length of the board. It is important that the gold pins are not bent when removing the board.

(3) Replace the old PC-327 board with a new one by placing it loosely on top of the DH200s. Ensure the board end containing connector P1 is oriented the same as the board just removed. Inspect and make sure that all the gold pins fit easily into the female end of the connector on the DH200 transducers. Press the board down evenly until all pins are firmly seated.

(4) Install the two (2) Phillips-head screws to secure the PC-327 to the DH200s. Be careful not to over-tighten. Install the wiring harness to connector P1 of the PC-327, **ensuring proper pin 1 location**. **(Pin 1 of the ribbon cable has a red stripe while pin one of P1 will contain a square solder pad on the PC-327.)**

(5) Carefully align the gasket on the top plate, ensuring it is free of contaminants. Re-install the module electronics into the extrusion case. Ensure that the alignment posts in the module's bottom panel align with the PC-327 or PC-322 electronics support brackets when placing the top panel and electronics back into the housing.

(6) Replace the screws that secure the top panel to the scanner housing and tighten. Do not over- tighten; 7-9 inch-pounds torque should be sufficient.

(7) Test your scanner to ensure proper operation.

#### 5.1.3.2 PC-322/323 Main Board/PowerPC Daughter Board Assembly

The following procedures should be used for replacement of the PC-322/323 Main Board/PowerPC Daughter board assembly. Use the tools and follow the general warnings already described in **Section 5.1.1**.

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Carefully remove any attached wiring harnesses from connectors P3 and P6 of the PC-322/323 board assembly. This will require cutting one nylon tie-wrap attached to the center mounting bracket. The wiring harness from P1 will be disconnected in the following step.

(3) Remove the three (3) 2-56 Phillips head screws securing the PC-322/323 assembly mounting brackets to the top plate. These screws will be in line with the PC-322/323 LEDs that protrude through the top plate. Carefully lift the board out of the top panel. Remove the wiring harness from P1. See **Figure 5.3**.

**Figure 5.3**
**PC-322/323 Assembly**

(4) Install the wiring harness from the circular connector attached to the top plate onto P1 on the new PC-322/323 assembly.

(5) Place the new PC-322/323 assembly so that its connectors and LEDs protrude through the top panel, dressing the wiring harness from P1 so that no more than one layer of the harness will be trapped between the board assembly and the valve assembly. **Loosely** install the three (3) 2-56 screws to secure the PC-322/323 assembly mounting brackets to the top panel. (To ease reassembly, they will be tightened after installing the electronics back into the module case.)

(6) Reinstall any previously installed wiring harnesses on connectors P3 and P6 of the PC-322/323 assembly. **Ensure proper pin 1 orientation when installing these connectors**. ***(Pin 1 of the ribbon cable has a red stripe while pin one of P1 will contain a square solder pad on the PC-327.)***

(7) Install the wiring harnesses so they are dressed away from, and will not be pinched or punctured when the alignment posts enter the holes in the assembly mounting brackets. Install the module electronics into the extrusion case, ensuring the alignment posts in the module's bottom panel align with the holes in the PC-322/323 assembly mounting brackets. Ensure that there are no conductors from the P1 harness pinched between the top plate and the extrusion. Ensure that the top plate gasket is properly installed. Install the screws that secure the top panel to the housing. Tighten the three (3) screws attached to the PC-322/323 assembly mounting brackets.

(8) Test your scanner to ensure proper operation.

### 5.1.3.3 Remove and Replace PC-323 (Daughter board) on PC-322 (Main PCB)

(1) Remove the two (2) Phillips-head screws that hold the PC-323 onto the PC-322 board. (**Figure 5.3a**)

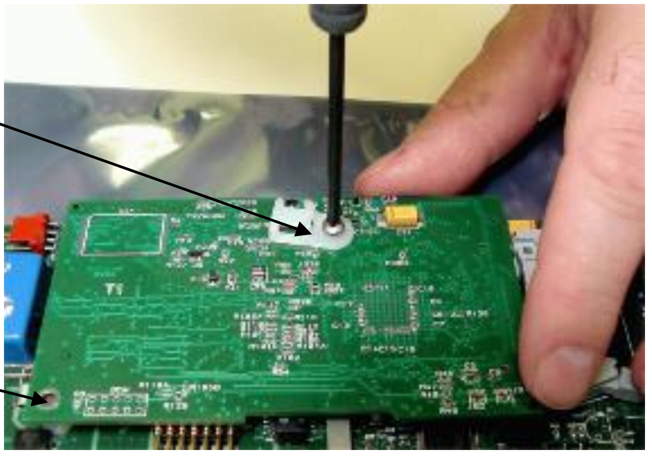



**Figure 5.3a**
**Removing PC-323 Daughter Board**

(2) Gently rock the PC-323 board back and forth to loosen it and then lift straight up to remove it. Place the old PC-323 in an electrostatically-protected bag for possible repair at our factory.

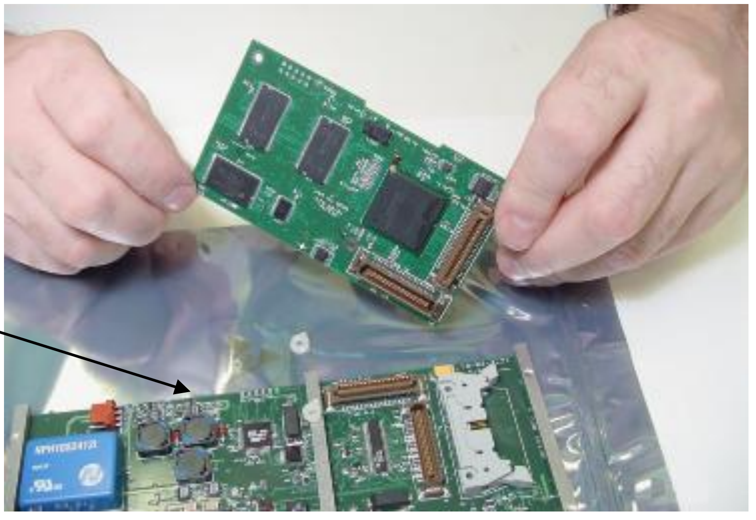



**Figure 5.3b**
**PC-323 Daughter Board Removed froom PC-322**

(3) Remove the new PC-323 board from its electrostatically-protected container**.** Ensure the nylon spacer is in place on top of the mounting bar and over the threaded hole. (See above photograph, **Figure 5.3b**). Align the two (2) 40-pin connectors and press the board into place.

Secure the PC-323 board in place using the long screw through the mounting bar and the short screw into the hex standoff.

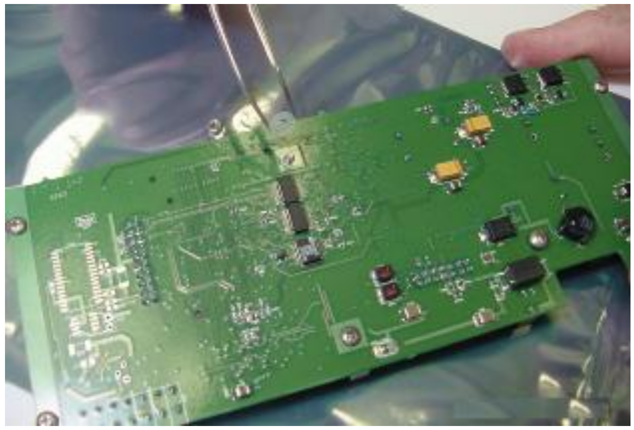


**Figure 5.3c**
**PC-322 Board**

(4) Turn the assembly over**.** Replace the nylon washer and secure the nut to the back of the long screw going through the mounting bar as depicted in **Figure 5.3c**.

(5) Reassemble the scanner as previously described and test for proper operation.

## 5.1.4 Replacement of Transducers

Your **Model 9116** has *internal* DH200 pneumatic transducers, as well as an *internal* calibration manifold with associated valves and O-rings. All these elements occasionally require service or replacement as described in the following sections.

Following is a step-by-step procedure to replace a DH200 transducer in a **Model 9116** Intelligent Pressure Scanner. Use the tools and follow the general warnings already described in **Section 5.1.1**.

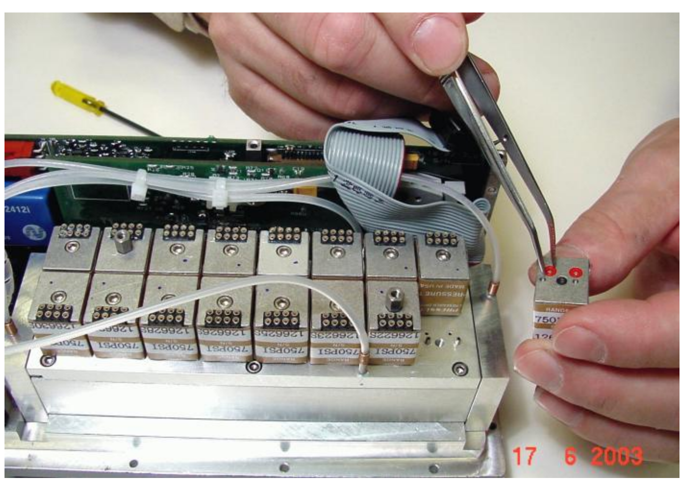



**Figure 5.4**
**Top View of DH200**

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Remove the PC-327 Analog board as described in **Section 5.1.3.1**. Lay the circuit board aside on an anti-static surface.

(3) Remove the retaining screw from the desired DH200 transducer. Lift the transducer straight up to remove it. Make sure that the two (2) O-rings remain with the transducer as it is removed from the adapter plate. Ensure that the adapter plate O-ring sealing surface is clean and free of contaminants. See **Figure 5.4** (above).

(4) Replace the DH200, making sure that the electrical connections are located on the outer edge of the cubic design. Be sure that the two (2) O-rings are in place on the DH200 and that O-ring surfaces are free of contaminants. The DH200 must fit the guiding pins smoothly and be aligned with all other DH200 transducers. Tighten the retaining screw to 40 inch-ounces ±5 inch-ounces of torque.

(5) Replace the PC-327 Analog board as described in **Section 5.1.3.1** and reassemble the module. Ensure that the two hex-head standoff screws are installed on DH200 positions 2 and 15 and that they align with the two PC-206 mounting holes.

(6) Test your scanner to ensure proper operation.

## 5.1.5 Calibration Valve Solenoid Replacement

Following is a step-by-step procedure to replace the Calibration Valve Solenoids in a **Model 9116** Intelligent Pressure Scanner. All **Model 9116** scanners contain the purge and leak check calibration manifold and contain two solenoid valves. Use the tools and follow the general warnings already described at the start of **Section 5.1.1**. Refer to **Section 5.1.6.5** for details concerning solenoid O-ring replacement.

**Note**

| |
|---|
| **The hex-head standoff screws used on DH200 positions 2 and 15 are used to secure the PC-327. These hex-head screws should not be over-tightened or else the screw may break. (Recommended 40 inch-ounces for all DH200 screws)** |

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Carefully remove the two (2) Phillips-head screws from the top of the solenoid. Disconnect the solenoid from connector P6 of the PC-322 Main Board Assembly. See **Figure 5.5**.

(3) If the either the new or old solenoid does not have a pluggable wiring harness at the solenoid, the new solenoid wires will require crimp pins to be installed for insertion in the P6 mating housing. The proper crimp pin is Molex part number 08-56-0110. After installing the crimp pins to the solenoid wiring, remove the old crimp pins from the Molex P6 housing and insert the new solenoid's wiring. Ensure that the new wires are installed in the same position as the old wires.

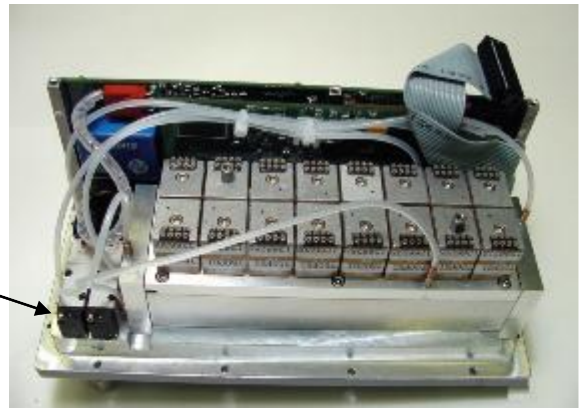



**Figure 5.5**
**Solenoids in Module**

(4) Ensure the three (3) solenoid manifold O-rings are present and free of contaminants. Replace the solenoid with the new one by carefully aligning and gently tightening the screws.

(5) Attach the wiring harness to the solenoid and connector P6 of the PC-322 Main Board Assembly.

(6) Reassemble the module.

(7) Test your scanner to enusre proper operation.

### 5.1.6 Replacement of O-Rings

MEAS calibration valves include static and dynamic O-ring seals. When used properly, the rated durability of the dynamic O-rings is in excess of 1,000,000 shifts of the calibration valve.

The procedures described below should be used for replacement of all the O-rings in the **Model 9116** Intelligent Pressure Scanner. Use the tools and follow the general warnings already described at the start of **Section 5.1**.

The material needed for the O-ring replacement can be acquired through the proper maintenance kit available from MEAS. Specifically needed for these procedures are calibration manifold and piston O-rings, PTFE cup seals, a fast evaporating cleaning fluid ( i.e. acetone, alcohol, Freon®, etc.), 50 psi dry air supply, and Krytox® fluorinated grease **(read product warnings and recommendations thoroughly)**. ***Service of O-ring seals requires a clean working environment.*** Introduction of contaminants to the O-ring or internal calibration manifold surfaces can result in internal pneumatic leaks. *Inspection for contaminates generally requires some type of magnification device, such as a microscope*.

### 5.1.6.1 DH200 Pressure Transducer O-Ring Replacement

Please note that the DH200 O-rings are used for static seals only. They will typically not require replacement unless exposed to improper liquid media (which will also damage other 9116 components). Following is a step-by-step procedure to replace a DH200 O-Ring should it be required:

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Remove the PC-327 Analog board as described in **Section 5.1.3.1**. Lay the circuit board aside on an anti-static surface.

(3) Remove the DH200 transducer(s) as described in **Section 5.1.4**. If more than one DH200 is removed, it is recommended to record their serial numbers prior to removal to ensure they are reinstalled in the same locations.

(4) Using tweezers, remove the two (2) O-rings from the DH200. Clean the O-ring cup with a lint-free applicator moistened with a cleaning fluid such as acetone, alcohol, Freon®, or any other substance that evaporates quickly and leaves very little residue. Remove any excess cleaner with the air supply as soon as possible. Do not blow air directly into the holes of the surface since that can drive the fluid into the transducer and/or rupture the silicon pressure transducer.

**Figure 5.6**
**DH200 Transducer O-Ring Replacement**

(5) With clean hands, apply a small amount of Krytox® fluorinated grease to the palm of one hand and rub it out evenly with your index finger. Place one new O-ring onto your greased palm. Work the O-ring around until it is evenly greased. The O-ring should shine when properly lubricated. There should be no white area of excess grease on the O-ring. Make sure there is only a thin film of lubrication on the O-ring. Using your greased finger, place the greased O-rings in the cups on the DH200. Ensure that no grease enters the hole that leads into the transducer.

(6) Reinstall the DH200 as described in **Section 5.1.4**.

(7) Repeat steps 3, 4, 5 and 6 for each set of O-rings in need of replacement.

(8) Replace the PC-327 Analog board as described in **Section 5.1.3.1** and reassemble the module.

(9) Test your scanner to ensure proper operation.

#### 5.1.6.2 Tubing Plate O-Ring Replacement

The following is a step-by-step procedure to replace Tubing Plate O-rings in a **Model 9116** Intelligent Pressure Scanner.

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Place the scanner with the tubing plate on a clean, lint free surface.

(3) Hold the top plate/calibration valve assembly with one hand, supporting the bottom assembly to prevent dropping when all screws are removed. Remove the six (6) Allen-head screws on the top plate that secure the valve assembly to the top plate.

(4) Carefully rotate or slide the tubing plate back and forth, pivoting on the guiding pin about 1/8" several times. This is done to loosen the O-rings from the calibration manifold. Lift the tubing plate straight up. Do not touch the calibration manifold.

(5) Inspect for the presence of shim washers around each of the six (6) screws. If washers are present, retain for use during reassembly.

(6) Remove and replace the O-rings needing maintenance, using the procedure described in **Section 5.1.6.1**. Note that the O-ring seals use an additional PTFE cup seal placed on top of the O-ring. These seals should be replaced as necessary. Note that these PTFE seals *do not* require the use of Krytox® grease.

(7) Examine the tubing plate and calibration manifold to verify that no contaminants are on either surface. This generally requires microscopic examination. Replace the tubing plate by slowly placing the plate on the calibration manifold. Make sure that the O-ring/cup seal side is down toward the pneumatic sliding manifold and the guiding pin on the calibration valve housing fits into the mating hole of the tubing plate. Also, ensure that shim washers, if used, are installed between the tubing plate and the calibration manifold assembly, in all six (6) locations.

(8) Replace the six (6) Allen-head screws that pass through the top plate to secure the calibration valve assembly. Tighten evenly, making sure that the screws are only finger tight plus 1/8 turn. It is important not to over tighten the screws since the pneumatic seal is made using dynamic O-rings.

(9) Reassemble the module.

(10) Test your scanner to ensure proper operation.

#### 5.1.6.3 Adapter Plate O-Ring Replacement

Following is a step-by-step procedure to replace Adapter plate O-rings in a **Model 9116** Intelligent Pressure Scanner. The adapter plate is located opposite of the tubing plate on the calibration manifold. All DH200 transducers are attached to the adapter plate.

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Remove the PC-327 Analog board as described in **Section 5.1.3.1**. Lay the circuit board to the side on an anti-static surface.

(3) Remove the six (6) 3/32" Allen-head screws that secure the adapter plate to the calibration valve housing. To remove the two (2) center screws, you must remove the DH200 transducers near the screws. Make sure to note the DH200 serial number and location. The plate should be gently lifted from the calibration housing.

(4) Carefully rotate or slide the adapter plate back and forth, pivoting on the guiding pin about 1/8" several times. This is done to loosen the O-rings from the calibration manifold. Lift the adapter plate straight up. Do not touch the calibration manifold.

(5) Remove and replace the O-rings needing maintenance using the procedure described in **Section 5.1.6.1**. Note that the O-ring seals use an additional PTFE cup seal placed on top of the O-ring. These PTFE seals *do not* require Krytox® grease.

(6) Examine the adapter plate and calibration valve surface to verify that no contaminants are on either surface. This generally requires microscopic examination. Replace the adapter plate by slowly placing the plate on the calibration manifold. Make sure that the O-ring is down towards the pneumatic sliding manifold and the guiding pin on the adapter plate fits into the mating hole of the calibration valve housing. Fasten the adapter plate evenly on all sides.

(7) Install the DH200 transducers that were previously removed. It is suggested to install them back in their original location.

(8) Replace the PC-327 Analog board as described in **Section 5.1.3.1** and reassemble the module.

(9) Test your scanner to ensure proper operation.

### 5.1.6.4 Calibration Manifold Piston O-Ring Replacement

Following is a step-by-step procedure to replace Calibration Manifold O-rings in a **Model 9116** Intelligent Pressure Scanner. There are eight (8) pistons, each with an O-ring, inside the calibration valve housing; one (1) on each end of the housing, and three (3) on each side of the calibration valve itself.

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Remove the PC-327 Analog board as described in **Section 5.1.3.1**. Lay the circuit board aside on an anti-static surface.

(3) Remove the tubing plate as described in **Section 5.1.6.3**.

(4) Using your index finger, shift the calibration manifold back and forth several times to loosen its connection with the adapter plate O-rings. Carefully lift the calibration valve housing with one hand and turn it over, letting the calibration manifold fall into the free hand. It is imperative that the calibration manifold does not fall on a hard surface since scratches on the manifold can result in pneumatic leaks.

(5) To remove the six (6) pistons from their slots on the manifold valve, hold the valve in one hand and apply air pressure of approximately 30 psi (200 kPa) to the C3/C4 input passages on the valve. The passages (0.043" diameter holes) are located on the side of the valve next to the *tubing plate*, one hole on each side of the valve. Pressure on one side will release three (3) pistons, and pressure on the other side will release the other three (3). If the pistons stick, apply a slightly higher pressure. Place your free hand over the calibration valve housing to prevent the pistons from coming out of the housing. Thoroughly clean the pistons with a fast evaporating cleaning fluid that leaves little or no residue (e.g., acetone, alcohol, Freon®, etc.) and dry with supply air. Replace the piston O-rings after lightly lubricating the rings with Krytox® fluorinated grease. Replace the pistons in their cavity by placing the O-ring side of the piston in first and then pressing the piston completely into its cavity with one finger.

(6) To remove the two (2) C1/C2 pistons from their slots on either end of the manifold valve housing, hold the manifold valve housing in one hand, and apply approximately 30 psi (200 kPa) to the two bulge tubes, one on either end of the housing end-plate. This will result in the pistons being forced out of their cavity. If the pistons stick, apply a higher pressure. Place your free hand over the calibration valve housing to prevent the pistons from coming out of the housing. Clean the pistons, lubricate and replace the O-rings, and replace the pistons into their cavities as described in (5) above.

(7) Thoroughly clean the calibration manifold with a fast-evaporating cleaning fluid that leaves little or no residue (e.g., alcohol, acetone, Freon®, etc.). Replace the calibration manifold into the housing, making sure that the guiding pin fits into the slot of the manifold housing.

(8) Replace the tubing plate as described in **Section 5.1.6.3**.

(9) Replace the PC-327 Analog board as described in **Section 5.1.3.1** and reassemble the module.

(10) Test your scanner to ensure proper operation.

### 5.1.6.5 Solenoid Valve O-Ring Replacement

Following is a step-by-step procedure to replace the internal solenoid valve O-rings in a **Model 9116** Intelligent Pressure Scanner. The module contains two internal solenoid valves.

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Remove the solenoid valve by unscrewing the two (2) Phillips-head screws on top of the solenoid. Gently lift it out of the module. Be careful ***not*** to crimp the attached nylon tubing.

(3) Remove and replace the O-rings needing maintenance using the procedure described in **Section 5.1.6.1**.

(4) Replace the solenoid valve and gently tighten the screws.

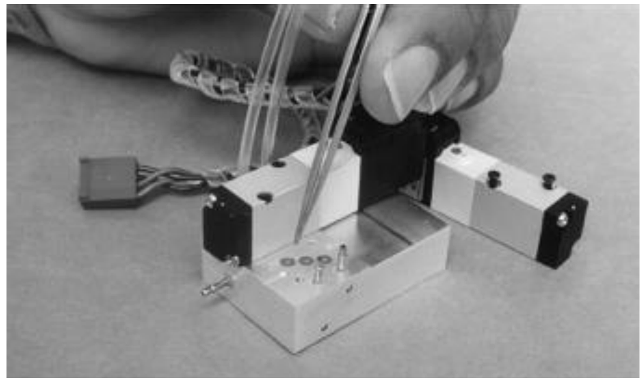


**Figure 5.7**
**Solenoid Valve O-Ring Replacement**

(5) Reassemble the module.

(6) Test your scanner to ensure proper operation.

# 5.2 Upgrading Module Firmware

All **Model 9116** Intelligent Pressure Scanner modules contain electronically re-programmable memory devices that store the module firmware. MEAS will provide new releases of module firmware for enhanced instrument performance whenever updates or modifications are made. All scanner modules may have their firmware downloaded via their Ethernet Host Port. This allows for firmware upgrade while the module is installed in its normal communications network environment. Any new firmware releases may be obtained free of charge by contacting the factory for a copy on CD-ROM or by downloading from the MEAS website www.meas-spec.com. Download links can be found on the home page and in the information page for each model (e.g., NetScanner). All firmware is stored as a self-extracting .ZIP file. Once downloaded from the internet, simply execute the download file to extract the archived file(s).

## 5.2.1 Upgrading Firmware Via Host TCP/IP Port

Your **Model 9116** Intelligent Pressure Scanner with Ethernet (TCP/IP) Host Port, new firmware may be upgraded by the host computer, or any computer on the TCP/IP network, directly via the module's Host Port. The special application called ***NetScanner*™ *Unified Software (NUSS)***, that runs under Windows® 95/98/2000/XP or Windows® NT, is provided for this purpose. It is recommended that ***NUSS*** (and any new firmware update file) be installed to a suitable subdirectory of your hard disk for better performance. Installation instructions for this support software are provided with the application. Ensure that the TCP/IP communications is properly configured for the PC running the application.

***NUSS*** is provided to all customers who have purchased **Model 9116** Intelligent Pressure Scanners. This application has its own User's Manual and both may be downloaded from our website, www.meas-spec.com.

**Note**

**If the unit loses power during the firmware update, the update may not be successful. When power is reapplied, the unit will return to operation and request that the update be repeated/continued. *If the update is not repeated/continued, the unit, while operational, may be operating with code that predates the most recent code previously in the unit.* Simply repeat the download to install the desired version of the code.**

**Chapter 6**

# Troubleshooting Guide

## 6.1 Ethernet Module Troubleshooting

### 6.1.1 Checking Module Power-Up Sequence

(1) Proper power to the module should first be verified. If possible, verify that the output of the module power supply is set within the range of 18-36 VDC. This should be nominally set for 24 VDC. Ensure the power supply setting is high enough to compensate for cable voltage drops if long interface cable lengths are used.

(2) Turn module power switch ON and verify the following top panel LED status following initial power-up :

- **PWR** LED should remain **ON**
  If this LED is not on, all other LED's will likely also be off. Check the 90DB, remote power supply (8491), or customer provided power supply to ensure the proper voltage (18-36 VDC) is being provided. Also verify that the power pins in the module interface cable are wired as described in **Section 2.3.2** and **Appendix D**

- **COL** LED will illuminate briefly upon power-up. This gives a visual indication that the LED is functional. Thereafter, the LED should remain **OFF**.

- **Tx** LED will illuminate briefly upon power-up. This gives a visual indication that the LED is functional. Subsequent activity on the **Tx** LED during the power-up sequence is indication that the RARP/BOOTP protocol is enabled. This will typically occur following the initial busy (**BSY**) LED cycle and continue until an appropriate RARP reply is received.

- **LNK** LED will illuminate briefly upon power-up. This gives a visual indication that the LED is functional. Thereafter, the LED will indicate proper connection to an Ethernet hub or switch, and should remain **ON**.

  If this LED is **OFF**, verify that the module is properly connected to the communications hub or switch. Verify proper power is applied to the hub. Also try connecting the 9116 cable to a different port of the hub. Note that most hubs have similar link LEDs to indicate proper connection to the hub itself. If present, verify that the hub link LED for the pressure scanner and the host computer are both active. If the hub is functioning correctly, verify that the communications pins in the module interface cable are wired as described in **Section 2.3.4.1** and **Appendix D**.

- **CAL** LED should remain **OFF**
- **PRG** LED should remain **OFF**
- Busy (**BSY**) LED will illuminate upon power-up. This LED will remain illuminated, only briefly blinking during the boot and self-check sequence. This sequence will last approximately 30 seconds, after which, the LED will be **OFF**. Subsequent activity of this LED indicates response of the unit to commands.

Any significant variation from this power-up LED sequence is an indication of a possible cabling or PC-322/323 assembly error. If the proper power-up LED sequence is not achieved after following the above suggestions, contact the Repair Department or the Applications Department at Measurement Specialties for additional assistance.

## 6.1.2 Checking Module TCP/IP Communications

If the LED indicators of the **Model 9116** are correct, the module is normally capable of proper communications. In order for communications to be established with a functional **Model 9116** (assuming correct interface cables are used), two user-controlled parameters must be met. First, the module must be configured to obtain a proper (and unique) module IP address. Second, the user's host computer must have its TCP/IP communications interface properly configured.

### 6.1.2.1 Module IP Address Assignment

Before an Ethernet **Model 9116** can communicate with a host computer, it must have a valid IP address assignment. As explained in **Section 2.3.4.1**, there are two methods for assigning an IP address to an Ethernet device, static and dynamic. The Static IP addressing protocol is the default method for IP address assignment in the **Model 9116.** This is primarily because it allows the module to assign its own IP address based on a factory default value. The Dynamic IP addressing protocol is slightly more complicated since it requires a Dynamic IP server to be present and properly configured on the network. Before host communications can be established, the user must ensure that the **Model 9116** has been assigned a known IP address through either Static IP or using a Dynamic IP server.

To determine whether Static or Dynamic IP addressing is enabled, observe the module **Tx** LED on module power-up. As explained in **Section 6.1.1**, if Dynamic addressing is enabled, the module **Tx** LED will flash one or more times during the power-up sequence. If the module receives a valid reply, the Busy (**BSY**) LED will begin to flash rapidly (appearing dim) and the **Tx** LED will remain **OFF**. If it appears the module received an IP server reply or that it is configured for the Static IP (default) addressing, proceed to **Section 6.1.2.2** to verify proper host TCP/IP configuration.

If the module does not receive a response to a Dynamic IP addressing request, its **Tx** LED will continue to flash with an increasing delay between **Tx** attempts. The Busy (**BSY**) LED will also remain **OFF** until a Dynamic IP addressing reply is received. If a Dynamic IP reply is not received, verify that a Dynamic IP server is present on the network. If the IP server is present, verify that it contains an entry for the **Model 9116** Ethernet hardware (MAC) address. Verify this address against the Ethernet address printed on the module label to ensure it has been entered correctly into the Dynamic IP server. After making the required changes to the IP server, repeat the above steps until the module receives a valid Dynamic IP reply.

If the user wishes to manually change the factory set IP address in a module, it may be done with the ***NUSS*** application program (described more fully in **Section 6.1.2.2**). To use it for this purpose, select the desired module on the application's *screen map* (left window), then press (click) the right-mouse button to get the module's pop-up *context* menu. From the ***NUSS*** menu, select **Configure, Network Options**. A new screen then appears that will accept a new IP address (and other network parameters). After the new address is sent, the module must be "re-booted" (another choice on the *context* menu) before it will take effect.

**Note**

**Model 9116 modules are factory-configured to use a 200.xxx.xxx.xxx IP address with a 192.0.0.0 subnet mask. These addresses were chosen with the understanding that the modules would run on a totally private network. Addressing errors may occur if modules are connected to a company internal network or if the modules are connected to the Internet. If you are not sure about the configured networking scheme, please consult your network administrator.**

**Note**

**Model 9116 modules are currently designed to use RARP protocol and BOOTP protocol for Dynamic IP address assignment. When placed in Dynamic addressing mode, (through the TCP/IP protocol 'w1301' command), the modules will first try to resolve their addresses using RARP protocol. If no RARP server can be found, the modules will then use the BOOTP protocol. The modules will alternate between these two protocols until a response is received and an IP address is assigned. If you are not sure about these protocols, or if your modules should be using them, please contact your network administrator.**

### 6.1.2.2 Host IP Address Assignment for Windows® 95/98/2000/XP/NT

**Note**

**A simple Windows® 95/98/2000/XP/NT BOOTP/RARP server is available free of charge from Measurement Specialties. For additional information on the BOOTP Lite application, contact the MEAS Sales or the Applications Support Department. The application can also be downloaded from our website www.meas-spec.com.**

In order to communicate with the Ethernet **Model 9116**, the host computer must also be configured with an appropriate IP address. For Windows® 95/98/2000/XP and Windows® NT, a typical configuration is described below. Note that this configuration assumes that a host PC Ethernet adapter is installed and not in use for any other TCP/IP application. If your Ethernet adapter is used for other TCP/IP communications, contact your MIS or network administrator to determine proper host IP address and subnet mask configurations before proceeding.

Activate the Windows® control bar (left click the **START** icon). Select the **SETTINGS** line followed by the **CONTROL PANEL** folder. In the **CONTROL PANEL** folder, select the **NETWORK** icon. Once in the **NETWORK** setup, select the tab labeled **CONFIGURATION**. Scroll through the list of installed configuration protocols. Select the one labeled '**TCP/IP->xxxx**' where xxxx will typically identify your Ethernet adapter card. There may be other TCP/IP protocols listed for other items such as dial up adapters, these are not used for the **NetScanner™ System** Ethernet configuration. If the TCP/IP protocol is not listed in the configuration menu, left click the **ADD** button. Continue by selecting to add a **PROTOCOL**. Select **MICROSOFT** from the Manufacturers list. Then select **TCP/IP** from the networks protocol list.

Once in the proper TCP/IP protocol setup, select the '**IP Address**' tab. Click on the button to enable the field '**Specify IP Address**.' Once selected, the fields for IP address and Subnet will be enabled. In the IP address, enter a TCP/IP address for your host computer. An IP address of 200.200.200.001 will work if the **Model 9116** is using the factory default IP address. If the leftmost fields of the **Model 9116** module IP addresses are different than the factory default of 200.20x.yyy.zzz then the leftmost fields of the host computer's IP address must match the module's leftmost IP address field. In the Subnet field a value of 255.0.0.0 can be entered for most configurations.

When these fields are entered, click the **OK** icons until Windows® prompts you to restart your computer. (Windows® 95/98 only). Once the computer has restarted, it should be capable of communications with the Ethernet **Model 9116** module.

#### 6.1.2.3 Verifying Host TCP/IP Communications

At this point, the **Model 9116** module should be configured to obtain its IP address through either static (default) or dynamic IP addressing. The module's IP address must be assigned and known in order to proceed. The host computer has also been configured for TCP/IP protocol and assigned an IP address compatible with the **Model 9116** IP address. A simple method to verify proper operation is through the ***ping*** utility. This is a simple TCP/IP utility that is found in Windows® 95/98/2000/XP/NT as well as most other TCP/IP packages. The ***ping*** utility simply sends a test packet to the specified IP address and waits for reply to be returned. **Model 9116** Ethernet modules are programmed to reply to these ***ping*** requests.

To run the ***ping*** utility from Windows® 95/98/2000/XP/NT, follow these steps. Left click the Windows® **START** button. Move the mouse pointer to '**RUN**' and left click on it. At the prompt type **'ping xxx.xxx.xxx.xxx**' where xxx.xxx.xxx.xxx represents the IP address of the device to test. The IP address of an Ethernet **Model 9116** module should be used. A small DOS window will appear as the ***ping*** application executes. The ***ping*** program will either report that a reply was received or that it failed to receive a reply. If the ***ping*** application reported receiving a reply, the host computer and the **Model 9116** module are both properly configured for TCP/IP communications.

If an error free ***ping*** reply was not received, rerun the ***ping*** application using the IP address of the host computer. This will verify if the TCP/IP protocol was properly configured on the host computer. If a ***ping*** reply was not received, verify the TCP/IP installation steps for your host computer. Also verify that the host computer is configured for the proper IP address and subnet mask.

If the ***ping*** test of the host computer's IP passed, while the ***ping*** of the **Model 9116** module failed, check the following possible sources for error:

- Ensure the **Model 9116** module's IP has been assigned (as explained in **Section 6.1.2.1**) and that the correct IP was used for the ***ping*** test.

- Ensure the IP address of the host computer and the **Model 9116** module are not duplicated on the network.

- Ensure the link LEDs are active on the scanner and the Ethernet hub or switch to which it is attached. Also ensure the link LEDs are active on the host computer's Ethernet adapter and the hub or switch to which it is attached.

- Ensure the Ethernet adapter card installed in the host is properly configured without conflict. In Windows®95 this can be verified by entering the **CONTROL PANEL** under **SETTINGS**. Under **CONTROL PANEL,** select the **SYSTEM** icon. When the **DEVICE MANAGER** tab is selected, a list of all installed hardware devices will be displayed. Any possible hardware conflicts will be marked in this list with a yellow warning symbol next to the device in question.

- Ensure the Ethernet adapter is configured for 10 Mbit/Sec. Many adapters are capable of higher speeds that are not compatible with the **Model 9116** modules.

## 6.2 Zero and Gain Calibration Troubleshooting

Incorrect pneumatic setup or incorrect command usage when executing a module's Re-zero or Span calibration command (see **'Z'**, **'h'**, and **'C'** commands in **Chapter 3**) can result in unexpected module operation. A common source of errors during these operations is incorrect control of the module's internal calibration valve and pneumatic inputs.

Pressure connections are described in **Chapter 2** while details of calibration procedures are described throughout **Chapter 4**. Some common errors and problems are listed below. These common problems apply primarily to **Model 9116** with its internal transducers and calibration manifold.

- The module's *supply air* input is either not attached or does not provide enough pressure (less than 65 psig) to shift the calibration valve. This results in the calibration valve remaining in its current position even though module commands have requested movement of the valve.

- The module's calibration valve is not placed in the correct position before executing the Span calibration command (***Calculate & Set Gain***). This command will not automatically shift the valve to the CAL position before taking data (as the Re-zero calibration command does). The user must manually control the calibration valve position using the ***Set Operating Options*** (**'w'**) command if the **CAL** and **CAL REF** inputs are to be used.

- The Re-Zero calibration command (***Calculate & Set Offsets***) will automatically shift the calibration valve unless the option is disabled with the ***Set Operating Options*** ('**w**') command. The valve will be placed in the **CAL** position (with a small delay) before taking Re-zero data. Afterwards, the valve will be placed in the **RUN** position.

- Zero *(offset)* and Span *(gain)* correction terms are not automatically saved in transducer nonvolatile memory. If they are not saved using the ***Set Operating Options ('w')*** command, they will be lost when module power is turned off. Verify that new coefficients produce valid data before saving them.

- When Span calibrating a multi-range unit, attach the calibration pressures to the individual measurement input ports of the range being calibrated and not to the **CAL** input port. Use of the common **CAL** input may result in over-pressuring lower range channels. When sending the ***Calculate and Set Gain*** (**'Z'**) command, ensure that the position field bits are set only for those channels that are attached to the calibration pressure.

- When using the standard ***Calculate and Set Gain*** (**'Z'**) command, the module firmware assumes, by default, that each particular transducer's full-scale pressure is present at its pneumatic/hydraulic input. All internal calculations of gain correction are based on the exact full scale pressure being applied to the transducers. If it is not possible to provide this exact pressure (as when using a dead weight tester), the alternate form of this command should be used. This allows the host to specify the exact upscale pressure applied to the transducers being calibrated.

- When using the standard ***Calculate and Set Offsets*** (**'h'**) command, the module firmware assumes, by default, that each particular transducer's zero pressure is present at its pneumatic/hydraulic input. All internal calculations of zero correction are based on an input pressure of 0.0 psi. If it is not possible to provide this exact pressure (as when calibrating an absolute pressure transducer), the alternate form of this command should be used. This allows the host to specify the exact minimum pressure applied to the transducers being calibrated.

## 6.3 User Software

For a complete description of all **NetScanner™ System** (and your **Model 9116**) software, please refer to the **NetScanner™ Unified Startup Software (NUSS)** User's Manual.

# Chapter 7

# Start-up Software

## 7.1 Introduction

The **NetScanner™ System Unified Startup Software (NUSS)** allows you to operate, from a Windows®-based host PC, a diverse network of pressure scanner modules and/or standard/calibrator modules of the **NetScanner™ System** type.

The **NetScanner™ System**, for which **NUSS** was designed, is a distributed Ethernet network (using TCP/UDP/IP protocols) that functions as a precision pressure data acquisition system.

**NUSS** integrates a diverse set of older "startup," "query," and "test" programs that were often very module-specific. **NUSS** recognizes each **Model 9116** module type it finds on the network and automatically provides that module with its appropriate functionality by dynamically adjusting the program's form and menu content. **NUSS** allows you to operate your **Model 9116** modules singly or together in selected groups without having to write any custom software, and without having to learn low-level commands. The software was designed to permit you to test almost every possible module function with a simple interactive point-and-click interface.

**NUSS** is provided to all customers who have purchased a **Model 9116** Intelligent Pressure Scanners. The software as well as the User's Manual may be downloaded from our website www.meas-spec.com.

# Appendix A

## All Commands – Quick Reference

| Type | Command id | Command Function |
|---|---|---|
| TCP/IP Commands | **A** | Power-Up Clear |
| | **B** | Reset |
| | **C** | Configure/Control Multi-Point Calibration (4 sub-commands) |
| | **V** | Read Transducer Voltages |
| | **Z** | Calculate and Set Gains (Span Cal) |
| | **a** | Read Transducer Raw A/D Counts |
| | **b** | Acquire High Speed Data |
| | **c** | Define/Control Autonomous Host Streams (6 sub-commands) |
| | **h** | Calculate and Set Offsets (Re-zero Cal) |
| | **m** | Read Temperature A/D Counts |
| | **n** | Read Temperature Voltage |
| | **q** | Read Module Status |
| | **r** | Read High Precision Data |
| | **t** | Read Transducer Temperature |
| | **u** | Read Internal Coefficients |
| | **v** | Download Internal Coefficients |
| | **w** | Set/Do Operating Options/Functions |
| UDP/IP Commands | **psi9000** | Query Network |
| | **psireboot** | Reboot Specified Module |
| | **psirarp** | Change Specified Module's IP Address Resolution Method (then Reboot) |

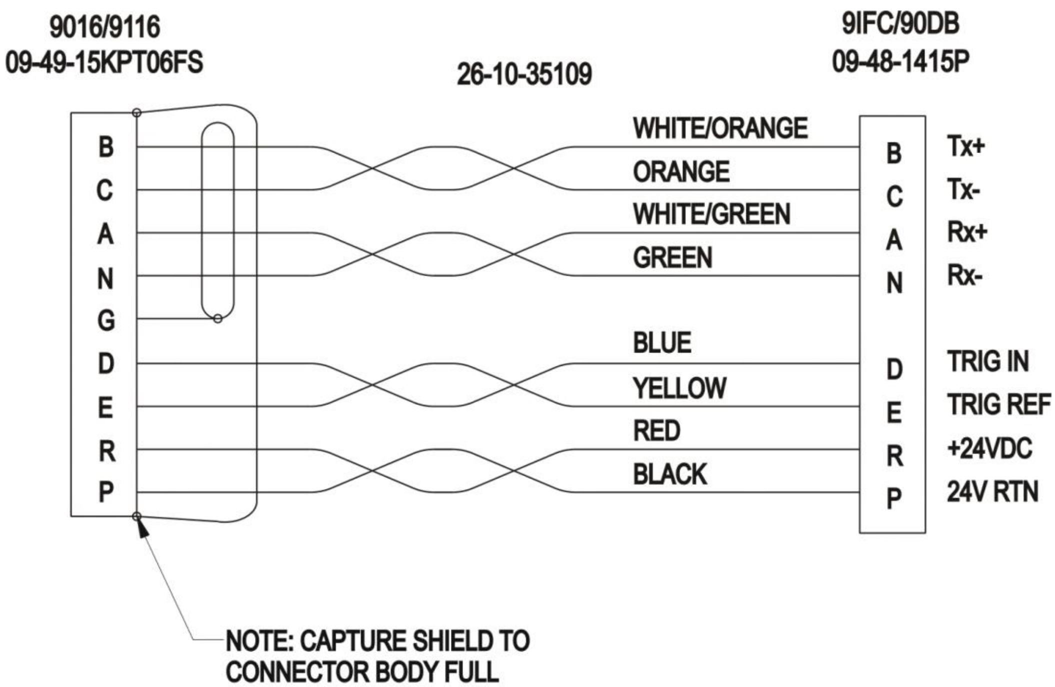
# Appendix B

## Model 9116 Response Error Codes

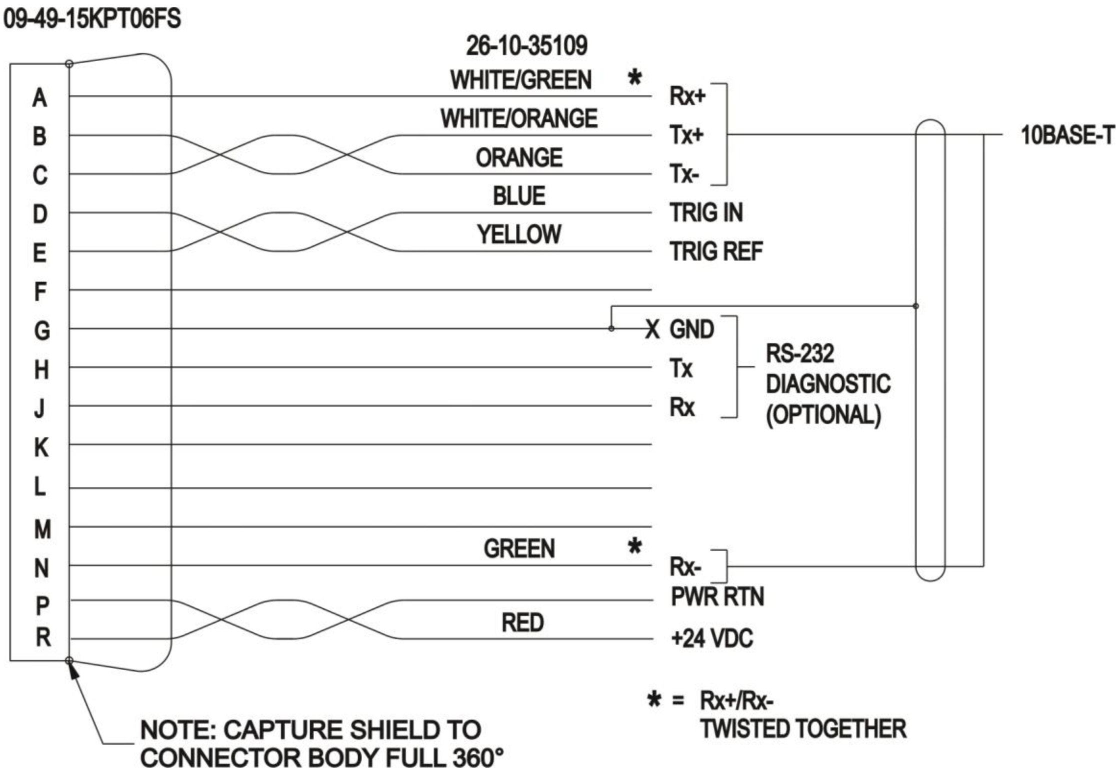
| CODE | MEANING |
|---|---|
| 00 | (Unused) |
| 01 | ***Undefined Command Received*** |
| 02 | Unused (by TCP/IP) |
| 03 | ***Input Buffer Overrun*** |
| 04 | ***Invalid ASCII Character Received*** |
| 05 | ***Data Field Error*** |
| 06 | Unused (by TCP/IP) |
| 07 | ***Specified Limits Invalid*** |
| 08 | ***NetScanner™ System error - Invalid Parameter*** |
| 09 | ***Insufficient source air to shift calibration valve*** |
| 0A | ***Calibration valve not in requested position*** |

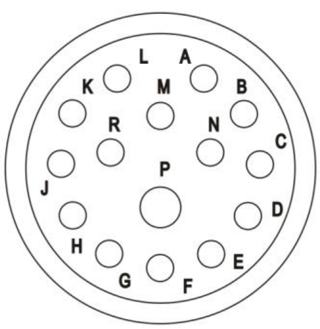
# Appendix C

## Cable Diagrams

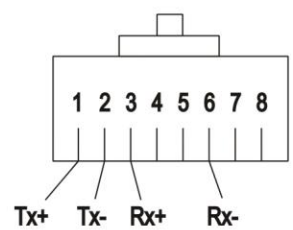



9016/9116 Ethernet Interface cable
9082 Cable



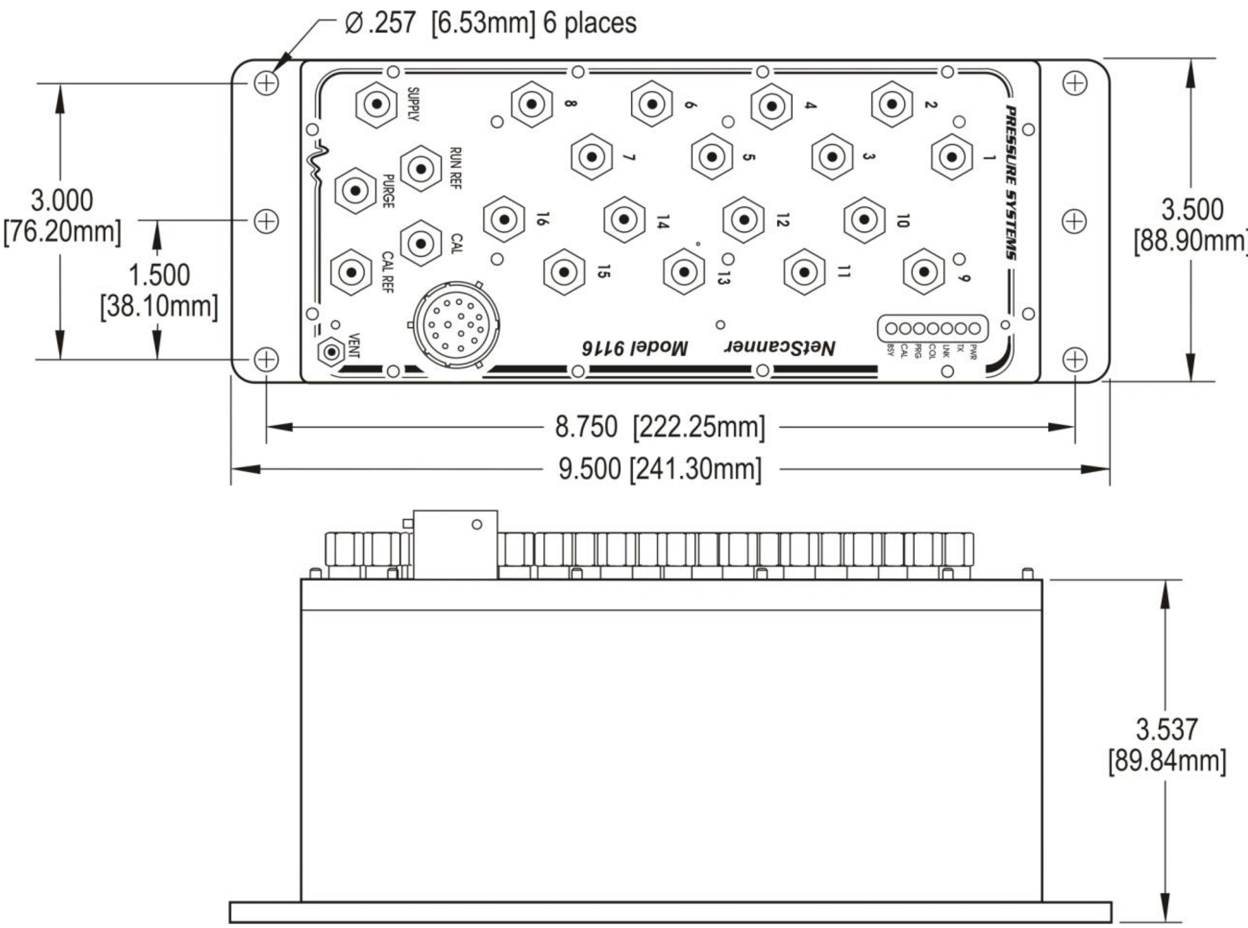

SOLDER CUP SIDE FOR CABLE




**Models 9016/916 Ethernet Interface**
**9082 Cable6**

# Appendix D

## 9116 Mounting Dimensions



# Appendix E

## Model 9116 Range Codes

The following range codes are stored in each DH200 pressure transducer. The range code of each transducer can be read through the Read Internal Coefficient ('u') command. *Standard* Range Codes are shown in ***Bold and Italics*.**

| Range Code | Full Scale Pressure | Minimum Calibration Pressure |
|---|---|---|
| ***1*** | ***0.360 psi (10" Water Column)*** | ***-0.360 psig*** |
| ***2*** | ***0.720 psi (20" Water Column)*** | ***-0.720 psig*** |
| ***3*** | ***1 psid*** | ***-1.0 psig*** |
| ***4*** | ***2.5 psid*** | ***-2.5 psig*** |
| ***5*** | ***5 psid*** | ***-5 psig*** |
| *6* | *10 psid* | *-5 psig* |
| *7* | *15 psid* | *-5 psig* |
| *8* | *30 psid* | *-5 psig* |
| *9* | *45 psia* | *0 psig* |
| ***10*** | ***100 psia*** | ***0 psig*** |
| ***11*** | ***250 psia*** | ***0 psig*** |
| ***12*** | ***500 psia*** | ***0 psig*** |
| ***13*** | ***600 psia*** | ***0 psig*** |
| ***14*** | ***300 psia*** | ***0 psig*** |
| ***15*** | ***750 psia*** | ***0 psig*** |
| ***16*** | ***10 psid*** | ***-10 psig*** |
| ***17*** | ***15 psid*** | ***-12 psig*** |
| ***18*** | ***30 psid*** | ***-12 psig*** |
| ***19*** | ***45 psid*** | ***-12 psig*** |
| 20 | 20 psid | -12 psig |
| 21 | 20 psia | 0 psig |
| 22 | 15 psia | 0 psig |

| Range Code | Full Scale Pressure | Minimum Calibration Pressure |
|---|---|---|
| 23 | 15 psid | -10 psig |
| 24 | 5 psia | 0 psig |
| 25 | 10 psia | 0 psig |
| 26 | 30 psia | 0 psig |
| 27 | 50 psia | 0 psig |
| 28 | 100 psia | 0 psig |
| 29 | 100 psia | 2.5 psia |
| 30 | 250 psia | 25 psia |
| 31 | 50 psia | 2.5 psia |
| 32 | 500 psia | 25 psia |
| 33 | 750 psia | 25 psia |
| 34 | 30 psia | 2.5 psia |
| 35 | 15 psia | 2.5 psia |
| 36 | 125 psia | 0 psig |
| 37 | 35 psid | -12 psig |
| 38 | 150 psia | 0 psig |
| 39 | 200 psia | 0 psig |
| 40 | 22 psid | -12 psig |
| 41 | 60 psid | -12 psig |
| 42 | 375 psia | 0 psig |
| 43 | 150 psia | 0 psig |
| 44 | 75 psia | 0 psig |
| 45 | 150 psia | 0 psig |
| 46 | 650 psia | 0 psig |
| 47 | 850 psia | 0 psig |
| 48 | 150 psia | 25 psig |
| 49 | 750 psia | 50 psig |
| 50 | 75 psia | 2.5 psig |
| 51 | 1.2 psid | -1.2 psig |

# Appendix F

## NetScanner™ System Products

| Model | Purpose |
|---|---|
| 9116 | 16-channel Intelligent Pressure Scanner with Ethernet TCP/IP Host Port. |
| 9022 | 12-channel splash-proof, ruggedized Media-Isolated Intelligent Pressure Scanner with Ethernet Host Port. |
| 9032/33 | Pressure Standard Unit with Ethernet TCP/IP Host Port. |
| 9034/38 | Pressure Calibrator Unit with Ethernet TCP/IP Host Port. |
| 9046 | Intelligent scanner for thermocouple and RTD measurements |
| 98RK | Scanner Interface Rack that holds up to eight (8) Model 9816 Intelligent Pressure Scanners. Rack provides power, pneumatic connections and hub circuitry for up to twelve (12) 10Base-T connections. |
| 9816 | Intelligent Pressure Scanner that requires **98RK** Scanner Interface Rack for power, pneumatic connections, and hub circuitry. |
| 90DC | Data Concentrator, containing power and 24 switched Ethernet ports, connections to as many as 24 **NetScanner™ System** modules. |
| 9096 | Series 9400 Interface Cable. |
| 9082 | Interface cable for connecting **NetScanner™ System** modules to switches and hubs. |
| 9400/9401/9402 | Media-Isolated Pressure Transducers for Models 9021 and 9022 |

# Appendix G

## Binary Bit Map

| Bit Value (if Set) | Bit Position | Binary Number | | | |
|---|---|---|---|---|---|
| 1 | 1 | 0000 | 0000 | 0000 | 0001 |
| 2 | 2 | 0000 | 0000 | 0000 | 0010 |
| 4 | 3 | 0000 | 0000 | 0000 | 0100 |
| 8 | 4 | 0000 | 0000 | 0000 | 1000 |
| 16 | 5 | 0000 | 0000 | 0001 | 0000 |
| 32 | 6 | 0000 | 0000 | 0010 | 0000 |
| 64 | 7 | 0000 | 0000 | 0100 | 0000 |
| 128 | 8 | 0000 | 0000 | 1000 | 0000 |
| 256 | 9 | 0000 | 0001 | 0000 | 0000 |
| 512 | 10 | 0000 | 0010 | 0000 | 0000 |
| 1024 | 11 | 0000 | 0100 | 0000 | 0000 |
| 2048 | 12 | 0000 | 1000 | 0000 | 0000 |
| 4096 | 13 | 0001 | 0000 | 0000 | 0000 |
| 8192 | 14 | 0010 | 0000 | 0000 | 0000 |
| 16384 | 15 | 0100 | 0000 | 0000 | 0000 |
| 32768 | 16 | 1000 | 0000 | 0000 | 0000 |

Decimal to Binary Conversion:

892 dec = 512 + 256 + 64 + 32 + 16 + 8 + 4

| | | | | |
|---|---|---|---|---|
| 0000 | 0011 | 0111 | 1100 | binary |
| | 3 | 7 | C | hexadecimal |